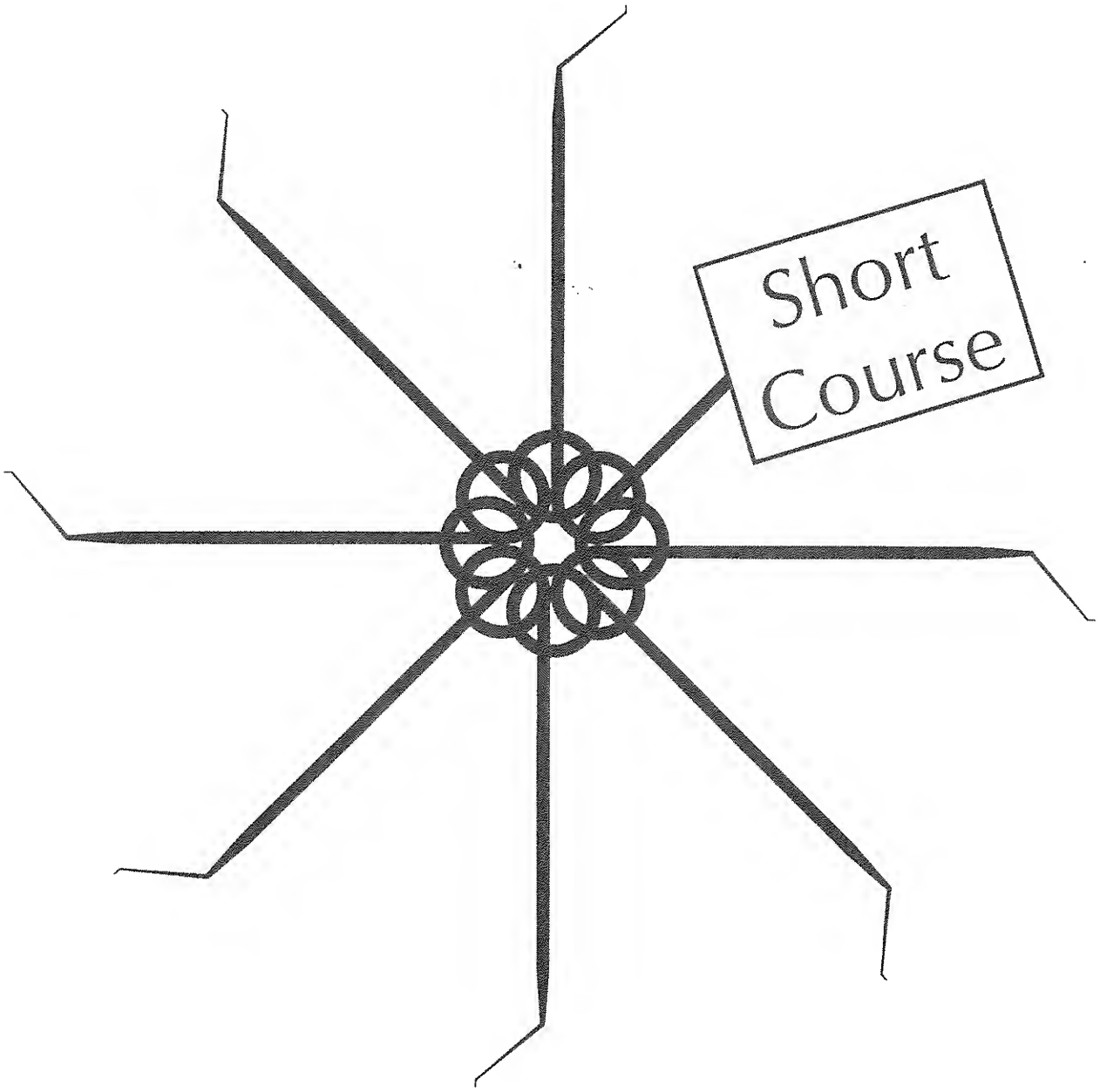
MI-6346-S
EP-6347-S
1994
Revised 2006

Successful Queen Rearing



MINNESOTA EXTENSION SERVICE
UNIVERSITY OF MINNESOTA
DEPARTMENT OF ENTOMOLOGY

SUCCESSFUL QUEEN REARING Short Course

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Produced 1995
Revised 2006

Acknowledgments

We wish to thank Dr. Cynthia Scott-Dupree for allowing us to reproduce some of figures from the Ontario Beekeeping Manual; Dennis McKenna from Fairview College, Alberta for sharing ideas on rearing queens in Canada; Steve Taber for teaching M. Spivak how to rear queens; Rebecca Melton for her assistance in preparing this manual and teaching the course, and all the beekeepers who try rearing their own queens using this manual.

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WHY REAR QUEENS IN THE NORTH?

The majority of queen bees used by beekeepers in the U.S. come from queen rearing operations located in the southern tier of states, including California and the southeastern seaboard. Traditionally, non-migratory beekeepers (i.e., those that winter their colonies in the North) obtain new colonies by ordering packages or nuclei from companies located in the South. The packages and nuclei are hived in Minnesota and the upper Midwest beginning in mid-April. Wintered colonies are requeened with individual queens purchased from southern queen breeders in May or June.

Migratory beekeepers transport all or a portion of their colonies to southern states for the winter. In early spring, divides are made and new queens are reared and introduced into the divides. The colonies with new queens are returned to the North for the summer. An estimated 500,000 colonies are transported every spring into the upper Midwest.

There are many variations on these management systems. The point is that the majority of package and queen rearing companies and southern wintering locations are located in areas where Africanized bees are expected to survive. Migratory beekeepers and queen rearing industries are now facing the challenge of avoiding the inadvertent sale and transport of Africanized bees to the North.

Model Certification Plan

In response to this challenge, the USDA, APHIS, beekeepers and bee researchers developed a Model Honey Bee Certification Plan in 1991 which outlines steps that can be implemented to ensure queen breeders and package industries in the South continue rearing and selling European queens and bees.

Basically, beekeepers who rear queens in areas where Africanized bees are found and sell or transport those queens out of the state must use certified European breeder queens. A certified breeder queen is any queen in which the progeny can be certified as being European in origin by a USDA approved morphometric identification procedure. The procedure involves taking precise measurements of the size and shape of a sample of worker bees. The probability that the sample is

Africanized or European is calculated using sophisticated statistical analysis. The morphometric tests have been used and improved for many years and are now quite reliable.

Any queen produced and mated in areas free of Africanized honey bees will not require certification. All certified breeder queens must be clipped and marked. Certified breeder queens can be used to produce other certified breeder queens and also used for drone producing colonies. The plan describes how to control mating in Africanized areas to ensure that European queens mate with European drones over 90% of the time.

Goals of This Course

The model certification plan is realistic and should be approved and adopted in many states. Nevertheless, many beekeepers are seeking alternative sources of queens, and migratory beekeepers are seeking more northern locations to winter their colonies. It is extremely unlikely that Africanized bees will establish permanent populations in the North. The primary goal of this course, therefore, is to teach northern beekeepers methods of rearing their own queens so they have alternative sources of European queens. The objective is to augment queen sources, not to replace southern queen sources.

There are advantages and disadvantages to rearing queens in northern locations. The advantages are that breeder queens can be selected that are adapted to northern conditions: long, cold winters, and short, intense nectar flows. Also, queens can be "custom selected" to perform the best under a particular beekeepers management style and system. The main disadvantage is that it is virtually impossible to rear queens and get adequate mating in April and May. There are ways around this problem which involve changes in timing and adoption of innovative methods.

Beekeepers are creative and independent people. Encouraging queen rearing in northern states will undoubtedly inspire new management systems and beekeeping technologies. The authors' goal in teaching this course is to learn improved queen rearing techniques from students after they have modified these basic techniques to fit their needs.

TIMING OF QUEEN REARING AND INTRODUCTION

The only difficulty rearing queens in Minnesota and the upper Midwest is deciding when to rear them. The weather must be favorable to ensure there will be ample nectar and pollen, and therefore, ample drones for mating. The next difficulty is deciding when to introduce the new queen into colonies.

Although generally considered very inconvenient, queens can be introduced after the honey supers have been removed from the colony in late summer or early fall. This can be an ideal time to introduce a new queen into a colony because she will rapidly lay a batch of brood which will provide new, young workers to survive the long period of confinement during the winter months. However, in the fall colonies are very large, irritable, and likely to rob each other. It is necessary to find and remove the old queen in order to introduce a new queen, which is often a difficult task in a populous colony. Also, most beekeepers are busy extracting honey and there simply isn't time to requeen colonies at this time of year.

The Canadians have been rearing their own queens for many years now, particularly since the borders were closed to the US. for queen importation in 1988. Many beekeepers have developed innovative methods for rearing and introducing queens at different times of year. For example, some beekeepers rear new queens when the weather allows in May or June, and introduce them into divides. The divides are wintered as singles (one brood box) either in indoor wintering sheds, or wrapped with insulation in groups of 4 or more and wintered outside. The divide becomes the honey producing colony the next year. Another method is to introduce a new queen into a divide in early summer as above, and then combine the entire divide with a large colony which has been dequeened after the honey flow. It is easier and more successful to introduce new queens into large colonies if they are introduced with frames of their own brood.

Again, beekeepers are innovative, creative people. Each beekeeper develops the most efficient techniques for his/her own operation and area. We encourage all beekeepers interested in rearing their own queens in the North to experiment with different methods and then share these methods with others. There is no "perfect" time to rear and introduce queens. The best way is the one that works best for you.

BIOLOGY OF QUEENS AND DRONES

THE QUEEN

- The queen lays all the eggs in the colony and is the mother of all individuals in the colony. Therefore, the genetic background of the queen has a very important influence on the colony's characteristics (e.g., temperament, disease resistance, etc.).
- The queen maintains colony cohesion through the production of queen pheromones.
- Some of the queen's pheromones inhibit ovarian development of the workers so they cannot lay eggs. If the queen is lost and no young brood is present, workers' ovaries will develop and they will begin to lay unfertilized (drone) eggs.
- The queen can control the sex of her offspring (see "Oviposition" below).
- The queen does not forage for food. She can feed herself from honey in the comb. However, workers feed her royal jelly and nectar through mouth-to-mouth exchange of food called *trophallaxis*.
- The queen normally lives 2-3 years, and may live up to 5 years. However, the most productive queens for efficient beekeeping are under 2 years old.

Anatomical Differences Between Queens And Workers

Characteristic	Queen	Worker
Pollen collection apparatus	absent	present
Glandular secretion to feed larvae	absent	present
Wax glands	absent	present
Sting	not barbed	barbed
Spermatheca	present	absent

Queen Reproductive Anatomy

- The reproductive tract of the queen consists of a pair of large ovaries in the abdomen. The ovaries are composed of a bundle of parallel tubules called ovarioles in which eggs are formed.
- A pair of oviducts lead from the ovaries to a single median oviduct which terminates in a flattened pouch, the vagina. The vagina opens beneath the sting.
- Connected to the vagina by a slender duct is a hardened sac, about 1 mm in diameter called the *spermatheca*, or sperm reservoir. It is covered with tracheal tubes which provide oxygen to the sperm and protect the sperm from extreme variations in temperature. The queen mates with many drones (see section on Virgin Queens and Mating), and the mixed sperm from all these drones is stored for the duration of the queen's life in the spermatheca.

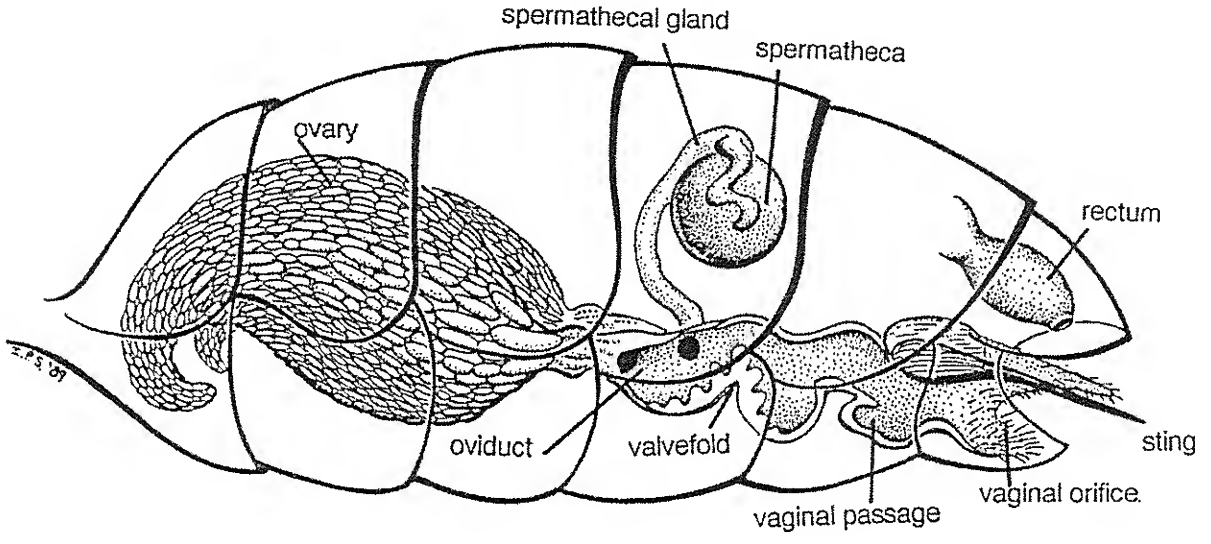


FIGURE 1.
Queen reproductive system. Source: Scott-Dupree, C. et al., 1993. *Ontario Beekeeping Manual*, University of Guelph, 174 pp.

Oviposition

- Eggs are formed within the ovarioles. An ovary contains from 260-375 ovarioles. A queen may lay 1500 eggs per day, which means approximately 5 eggs are produced per ovariole per day.
- If an egg is fertilized by one of the sperm stored in the spermatheca, the offspring will be female. If an egg is not fertilized by a sperm, the offspring will be male. Females possess two sets of chromosomes, one from the egg and one from the sperm, and are diploid. Males possess one set of chromosomes from the egg only, and are haploid. (The exception to this rule is when a queen is inbred and produces diploid drones - see section on Inbreeding).
- It is not clear how the queen determines whether an egg will receive sperm as it passes through the vagina. It may be that the valvefold (an invagination in the vagina) presses the egg against the opening of the spermatheca duct allowing one or more sperm to enter the egg. If the valvefold is retracted, the egg bypasses the duct and passes through the vagina without being fertilized.
- The size of the comb may also influence whether the queen will lay a fertilized, female-destined egg or an unfertilized, male-destined egg. The queen measures the cell diameter with her forelegs. Fertilized eggs are laid in smaller worker comb. Unfertilized eggs are laid in larger drone comb. Fertilized eggs are also laid in natural queen cups which are larger than worker cells and open downward.
- Environmental and seasonal changes influence whether eggs are laid in worker, drone, or queen cells, and whether the eggs and larvae will be cared for by the workers. In this respect, the workers have some control over the queen's oviposition.

CASTE DETERMINATION

- Both queens and workers are females that develop from diploid (fertile) eggs. Drones are male and develop from haploid (unfertilized) eggs. A fertilized or unfertilized egg takes approximately 3 days to hatch into a larva.
- Upon hatching, the female larva is neither a queen nor a worker. Any egg destined to be a female has the potential to develop into either a queen or a worker. It's caste is undetermined until it begins to feed. **The central tenant of queen rearing is that a fertilized egg may be reared into a queen or worker depending on the food it receives as a larva.**
- If the larva is to be a queen, the quality and quantity of the food differs from the food given to workers. Nurse worker bees feed queen-destined larva a rich glandular secretion called *royal jelly* throughout their entire larval development. Royal jelly is high in proteins derived from special glands in the workers' heads, and sugars derived from nectar. The sugars act as feeding stimulants, inducing the queen-destined larva to eat more food. The rate of food intake regulates the activity of a portion of the bee brain called the corpora allata which secretes a hormone called *Juvenile Hormone*, or *JH* The level of JH in the blood regulates the processes leading to the development of the queen caste. A high level of JH during the third day of larval development induces differentiation into a queen. A lower level during the third day of development induces differentiation into a worker.
- Workers are also fed royal jelly for the first three days of their larval life; however, the composition differs slightly from the royal jelly fed to queens. The sugar content is lower, and the ratio of glandular secretion is slightly different. Therefore, by the third day of larval development, the level of JH is lower in workers than it is in queens. After the third day, the composition of worker food changes dramatically to glandular secretions lower in protein and sugar content than royal jelly.

- Under certain circumstances, such as in emergency queen rearing, the workers may take 2-3 day old larvae that were originally destined to become workers, expand the cells around the larvae so they extend downward, and feed them queen royal jelly. These larvae will develop into queens. In some cases, however, the queens are smaller, have fewer ovarioles, and may not be as prolific as those reared from very young (12-24 hour) larvae. Some beekeepers requeen their colonies by "emergency" queen rearing; but this method runs the risk of producing inferior queens.

- The secret to rearing quality queens is to select very young larvae (12-24 hours old) and transfer, or *graft* them into queen *cups*. Given the right conditions, which the beekeeper carefully provides, the workers will feed the young larvae rich queen royal jelly throughout the queens' development.

Queen Rearing under Natural Conditions

- Queens are reared naturally by workers under three conditions:

  1. **when a colony is preparing to swarm**
  2. **when an old or failing queen is being superseded**
  3. **when a queen is accidentally killed and is replaced through "emergency" queen rearing**

- The most ideal conditions for queen rearing occur when a colony is preparing to swarm. At this time, there is ample pollen and nectar, colony populations are increasing rapidly, and the colony naturally is prepared to rear many queens. Sound queen rearing methods take advantage of this condition to rear quality queens.

- Queens are reared naturally in special cells that extend downward from the face or edge of the comb. The queen may lay a fertilized egg in a queen cell, workers may transfer eggs from worker cells to queen cells, or workers may enlarge a worker cell that contains a young larva into a vertical queen cell.

- When the larva is 5-6 days old (or 4-5 days after grafting), the cell is fully formed and will be sealed by worker bees.

After the cell is sealed, the larval queen spins a silk cocoon in the lower half of the cell. She stops eating royal jelly, straightens out with her head downward, and begins pupating.

- The queen remains as a pupa for 6-7 days. During this time, her tissues and organs completely transform from larval to adult features. On the fifth pupal day, the appendages begin moving and later the wings unfold. Rough handling of queen cells, or improper temperature control before the wings have expanded can result in deformed wings.

VIRGIN QUEENS AND MATING

- A virgin queen emerges from the cell about 15-16 days after the egg was laid (or 11-12 days after grafting). After emerging, she seeks out other sealed queen cells about to emerge and destroys them by cutting a hole in the side of the cell with her mandibles (mouthparts). She may sting the queen inside. When rearing queens, it is essential to isolate the queen cells from each other before the first queen emerges to prevent her from destroying the other queen cells.
- When a virgin queen is about 7 days old, she will make her first mating flight. She flies up to one mile away from the apiary (although she will fly farther in some instances) to a *drone congregation area* 30-130 feet above the ground (see following section on Drones). She will mate with an average of 10 drones (or a maximum of 20 drones) before returning to her hive. She may fly out on 2-3 successive days to complete mating if the first flight(s) are not successful, or if the weather is not conducive.
- The queen begins laying eggs 3-4 days after mating. She will continue to lay eggs the rest of her life, stopping only for a few months during the winter, or briefly before the colony swarms.
- **Approximately 10-14 days pass from the time the queen emerges from the cell to the time she begins laying eggs.**

DRONES

- Drones develop in larger cells than worker cells. They are fed a diet similar to worker larvae.
- Colonies will rear drones only when environmental conditions allow (i.e., there is sufficient pollen and nectar to support the drones), and when the colony population is large.
- Drones take approximately 24 days to develop from egg to adult. As adults, they become sexually mature within about 12 days. **Therefore, a minimum of 36 days elapse from the time a colony begins rearing drones to the time the drones are ready to mate. When rearing and mating queens, it is very important to ensure that drone maturation flights coincide with the queens' mating flights.**
- All the sperm are formed before the drone emerges from its cell, however, the drone cannot mate until the sperm have migrated into the seminal vesicles. If a young drone is properly fed and remains in the brood nest where temperatures are favorable for his maturation, the sperm will migrate 8-10 days after emergence. When drones are mature they move from the center of the brood nest and congregate on the outer combs where nectar is stored.
- Drones first leave the colony on orientation flights about eight days after emerging. When the drone reaches sexual maturity, he flies to a *drone congregation area* which is generally located within a mile from the home apiary, but may be 3-4 miles away. Thereafter, drones leave the colony every afternoon when temperatures are the warmest (between noon and 4:00 PM, weather permitting). At the drone congregation area, up to 10,000 drones will congregate 30-130 feet above ground waiting for a virgin queen to arrive. **The drones in any congregation area represent any number of colonies from apiaries or wild colonies in the vicinity.**
- The drones die after mating. The eversion of the copulatory organ (the endophallus) ruptures the reproductive tract of the drone. The end of the endophallus breaks off within the queen and remains within the sting chamber as the "*mating*

sign" and the dying drone drops away. Subsequent drones who mate with the queen dislodge the mating sign left by the previous drone when copulating. The queen bearing the mating sign of the last drone with which she mated returns to the hive. The workers remove the last mating sign from the queen.

- Whenever there is a dearth of nectar and/or especially pollen, the drone brood (in any stage of development) and adult drones are removed from the hive by the workers. In the fall, adult drones and remaining drone brood are removed from the colony because drones serve no beneficial purpose to the colony during the winter months. The evicted drones probably die of starvation or exposure.

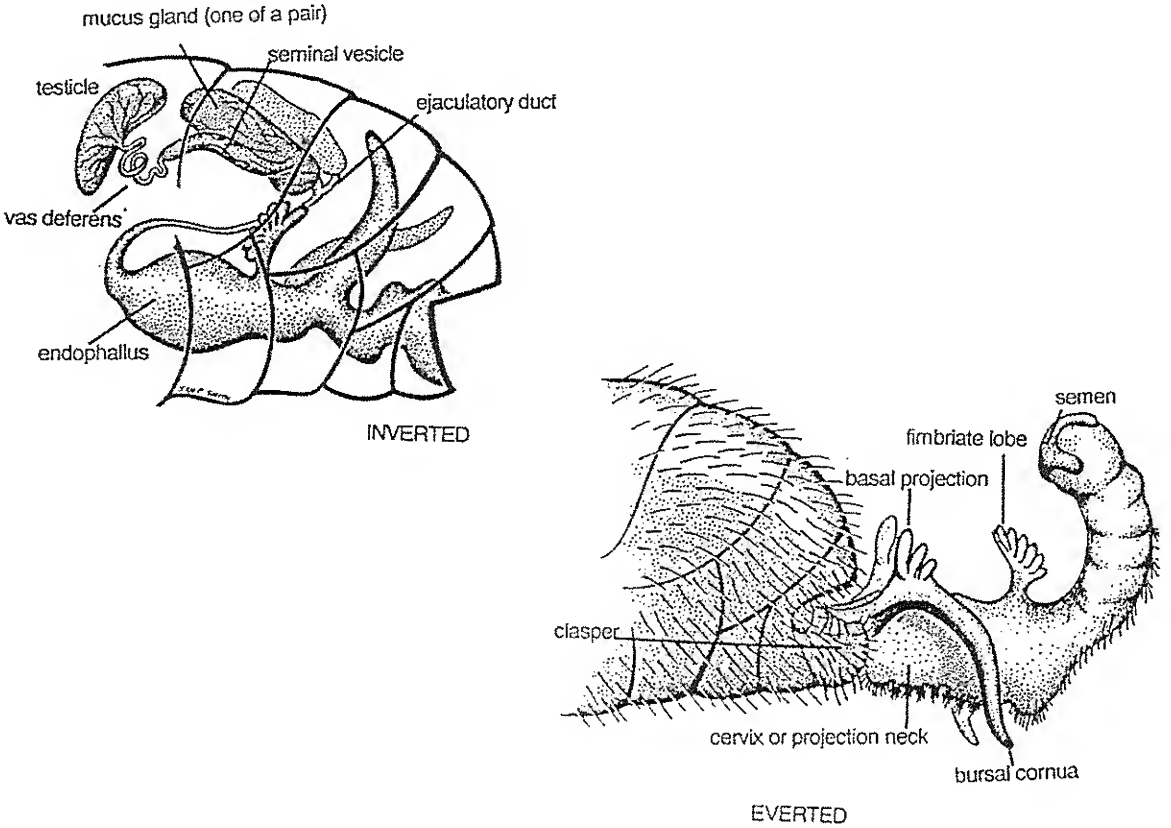
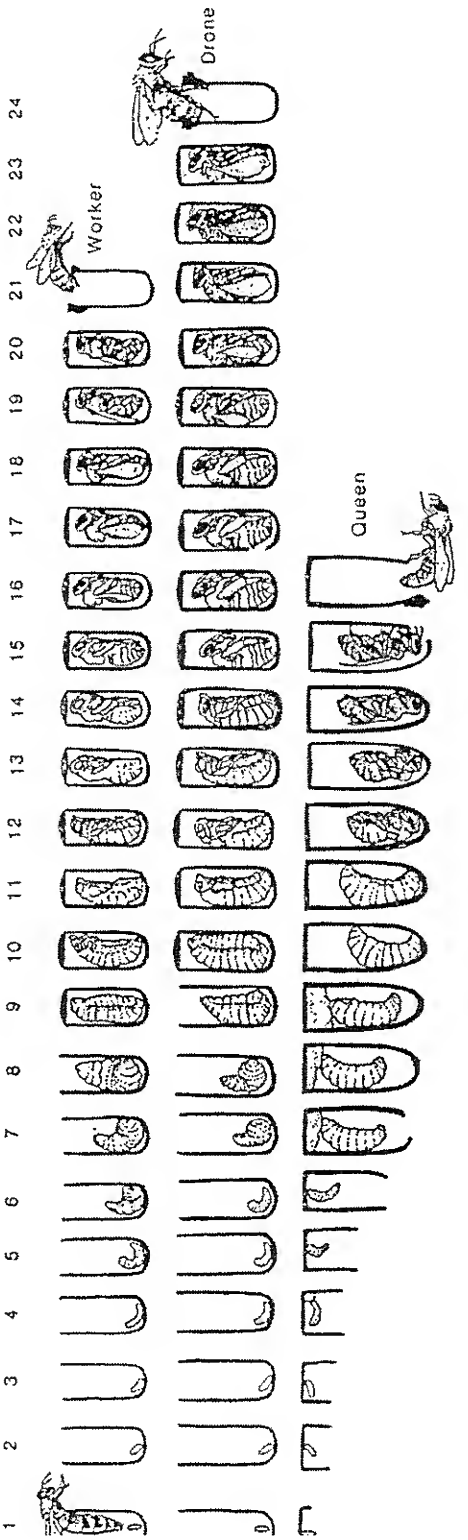


FIGURE 2.
Drone reproductive system. Source: Scott-Dupree, C. et al., 1993. *Ontario Beekeeping Manual*, University of Guelph, 174 pp.

FIGURE 3.
Development times of Queens, Workers and Drones. Source: Winston, M., 1987, The Biology of the Honey Bee. Harvard University Press, Cambridge, Mass.



STOCK SELECTION AND MAINTENANCE

- Stock selection and maintenance requires work and careful record keeping. Raising, selecting, and breeding your own queens is very rewarding. The advantages of custom selecting queen stock to fit personal management styles and preferences must be weighed against the disadvantages of purchasing queens from southern queen breeders where Africanized drones are prevalent.
- It is possible for any careful and willing beekeeper to apply selection pressure on his/her stock to improve the line of bees. It is important to raise healthy, quality queens and to keep track of the performance of these queens through careful record keeping of individual colonies. Paying attention to these two important steps will go a long way toward improving stock quality.
- It is also important to requeen colonies annually with queens from selected breeder colonies. Methods for selecting breeder colonies are outlined on the following pages. Beekeepers will notice improvement in their stock through selection solely on queen lines, if care is taken to avoid inbreeding by not using the same breeder colonies year after year. One way for hobby and part-time beekeepers to apply selection pressure and to control breeding stock is to form cooperatives.
- Ambitious beekeepers may wish to take further steps to ensure that their quality queens mate with quality drones from desired lines. It is difficult to ensure that queens mate with desirable drones because they mate high in the air with drones from surrounding managed and feral colonies. Controlled mating can be obtained in isolated mating areas such as an island out of drone flight range (> 5 miles) from the mainland. Finding such a location, however, is often impractical.

- An alternative method of controlling mating is through instrumental insemination of queens. This method is very effective because the beekeeper hand picks drones from selected colonies, collects semen from these drones, and inseminates selected queens using a specialized insemination apparatus. For most beekeepers, inseminating queens is not practical because it is labor intensive and requires specialized equipment (microscope and insemination apparatus). Inseminated queens are rarely used for production purposes (i.e., in honey producing colonies). They are more commonly used as breeder stock in queen breeding operations or for research purposes. We encourage beekeepers that are sincerely interested in using inseminated breeder queens in their operations to take a course on Instrumental Insemination.

BREEDER COLONIES

- The colonies from which queens are produced are called "breeder colonies" and the queens that head breeder colonies are called "breeder queens."
- Breeder colonies should possess all of the traits the beekeeper wishes to retain in his/her stock. Breeder colonies must be carefully selected using very strict criteria which the beekeeper chooses. What constitutes a "good" or "bad" characteristic is a matter of opinion, and is influenced by the beekeepers management system (e.g., hobby, migratory) and geographic location.
- The most basic characteristics to look for when selecting breeder colonies are:

  1. **Good honey production**
  2. **Good wintering ability**
  3. **Gentle temper and ease of management**

  At first glance, these characteristics may seem overly simplified. However, consider the problems that affect bees and beekeepers today--tracheal and varroa mites, American foulbrood, chalkbrood, and Africanized bees-- to name a few. If colonies possess these three simple traits, it actually has profound significance. A colony that produces large amounts of honey and winters well indicates that it is probably disease free and has low (or no) mite infestations. It also indicates that the colony has a low tendency to swarm and builds up rapidly in the spring so that there are large numbers of bees of foraging age before the honey flow. If the colony is gentle, easy to manage, and winters well in the North, it indicates that it probably is not Africanized. Diseases, mites, and a tendency to swarm will result in colonies that do not build up rapidly in the spring, do not produce large amounts of honey, and do not winter well. Africanized colonies will not be consistently gentle nor easy to manage, they may swarm frequently, and they probably will not winter well in the North.

- This step is of course optional, but consider it seriously. It will be easier to select breeder colonies if they are not treated for diseases and mites. Colonies that survive without treatment may show resistance, and are highly desirable breeder stock. The short-term implications of not treating colonies may be economically devastating. The long-term implications, however, may be very worthwhile.
- These two steps are **NOT OPTIONAL**.

  1. **Maintain precise records of the breeder colonies. Make sure your breeder queens are marked.** See the sections on Record Keeping and Marking Queens.

  2. **Breeder colonies should pass the selection criteria test over a year's time. Rapid selection based on one or two inspections in the spring or fall may be very misleading and lead to the propagation of undesirable characteristics.**

DRONE MOTHER COLONIES

- For most hobby and part-time beekeepers with one apiary, it is not possible to control the drone stock with which their queens mate. The queens mate in congregation areas composed of drones from many different apiaries and wild colonies in the vicinity. These beekeepers can only depend on controlling the queen line. Queen selection is a slower process, but will be adequate if done consistently.
- For beekeepers with many apiaries in a general vicinity, it is possible to select drone mother colonies to rear drones for mating. Drone mother colonies should be selected using the same criteria as the breeder colonies. They should be from diverse sources; that is, the queens in the drone mother colonies should not all be sisters or from the same line as the breeder colonies, which would lead to inbreeding.
- In the model national certification plan for maintaining European colonies in Africanized areas, it is recommended that for every 1000 virgin queens that will be mating, there should be 60 drone mother colonies in surrounding apiaries. This same procedure should work to maintain selected lines of European bees anywhere by saturating the mating area with the desired drones.
- Queens do not necessarily mate with drones from the same apiaries, so it is important to place the drone mother colonies in apiaries within a mile of the apiary from which the queens fly.
- The drone mother colonies should be provided with ample (1-3 full frames) drone comb (drone comb foundation is commercially available). The drone mother colonies will need large quantities of pollen and nectar to rear healthy drones. Large quantities of pollen is the secret ingredient in stimulating colonies to rear drones.
- Careful planning and timing is necessary to produce mature drones in time for queen mating. Refer to the Queen Rearing Calendar, pages 72 & 73.

INBREEDING

- Here is the scientific (and fascinating!) explanation of the genetic effect of inbreeding, and how the worker bees respond to inbred larvae. Inbreeding leads to homozygosity at the sex determining locus. What does that mean? The sex determining locus refers to the location (=locus) of the gene along the chromosome that determines sex. In diploid organisms (people, most animals, queens and worker honey bees) there are two sets of chromosomes; one from the mother's egg and the other from the father's sperm. In bees, the sex determining gene comes in different copies, called alleles. When the alleles on the two chromosomes are different (heterozygous), the diploid egg becomes a viable female. However, if the alleles are alike (homozygous) due to inbreeding, the diploid larva that hatches from such an egg is an abnormal male (a diploid male) instead of female. When diploid drones hatch from the egg, the larvae are eaten by the worker bees, leaving empty cells among the cells of the brood comb. This is often hard to comprehend, but it is one of the fascinating aspects of honey bees.

- The main point is that queens that are inbred produce weak colonies. Inbreeding is detected by inspecting the queen's brood pattern. If the queen is inbred, her brood pattern will be spotty because many of the abnormal (diploid drone) larvae are eaten by workers. Other times a spotty brood pattern may occur is when the brood is diseased or the queen is failing. If the diseased brood is detected and removed by workers (through hygienic behavior), empty cells will be evident within the brood pattern. Whether a spotty brood pattern is due to inbreeding, disease or a failing queen, it is not desirable. The colony should be requeened and, if diseased, should be treated.

How to Avoid Inbreeding

- For beekeepers with one apiary who are not attempting to select drone mother colonies, inbreeding will probably not be a problem if different breeder queens are used each year. The first year, the daughter queens, even if they are all reared from one breeder queen, will mate with 10-20 drones from different apiaries which will promote outcrossing. The next year, use a different breeder queen. The use of the same breeder queen year after year will bring about a deterioration of the brood pattern. Observe the queen's brood pattern and do not rear queens from those colonies that have spotty brood.
- For beekeepers with several apiaries who select queen and drone mother colonies, it is important to rear queens and drones from several breeder colonies that were not used the year before. Do not requeen the drone mother colonies each year with all sister queens. The drones produced by sister queens will be highly related, which will greatly increase the chances of inbreeding.
- New breeder queens can be obtained by forming cooperatives with other beekeepers or purchasing new stock from a commercial queen breeder. It is important to introduce new breeder queens into your stock to maintain genetic variability.
- Keep accurate records of breeder queen and drone mother lines to avoid using the same lines every year.

A GENERAL OVERVIEW OF THE DOOLITTLE METHOD OF QUEEN REARING

The basic queen rearing technique outlined here is based on the Doolittle method. G. M. Doolittle developed this method in 1888 from a compilation of different methods practiced around that time. (For an excellent account of the history or queen rearing methods, refer to the last chapter in H. H. Laidlaw's book, *Contemporary Queen Rearing.*)

The method involves transferring, or *grafting,* 12-24 hour old larvae into artificial queen cups. The larvae at this stage are undifferentiated; that is, they may develop into queens or workers depending on how they are fed. The grafted larvae are given to a small, queenless and broodless unit called a *swarm box.* The swarm box contains 4-5 lb. of nurse bees, 2-3 frames of nectar and pollen, adequate ventilation, and water. The bees and grafted larvae are confined within the swarm box for 24 hours in a cool, dark place. Because the nurse bees are queenless and have no other larvae to feed they "want" to rear queens. Their glands which secrete royal jelly are well-developed, and they begin to feed the larvae and draw out the cells. The swarm box gets the new queens off to a good start. After 24 hours, the swarm box is opened and the grafted larvae, now doubled in size and floating in large amounts of royal jelly, are placed in a different colony called a *finishing colony.* The finishing colony is a very populous, queenright colony. The queen is confined in the bottom hive body (or bodies) by a queen excluder. The brood within the finishing colony has been manipulated so that the frames containing eggs and larvae are rotated above the excluder, and emerging brood and empty cells are moved into the box where the queen is laying below the excluder. Nurse bees move up above the excluder to feed the eggs and larvae. Manipulated in this way, the finishing colony also "wants" to rear queens. Why? Because it is VERY populous, has large stores of honey, new nectar and LOTS OF POLLEN, and therefore, has the impulse to swarm. Bees rear high quality queens when they are preparing to swarm, so the finishing colony provides ideal conditions for the continued feeding and incubation of the developing queen cells.

The queen cells are left above the queen excluder in the finishing colony for 9 days (or 10 days after they were grafted). They must be removed before the first virgin queen emerges, or she will destroy the rest of the queen cells. Upon removal, the cells are generally placed in *mating nuclei (nucs)*, or small queenless colonies, where they will emerge. About a week after emergence, the virgin queens will take their mating flight, and several days later will begin laying eggs.

For those people who find grafting larvae difficult, there are alternative methods which can be adapted to use with the Doolittle method. One alternative method uses a kit which eliminates the need to manually transfer larvae into queen cups. The use of these methods is described on page 64.

At first glance, the Doolittle method seems complicated and burdensome. However, with a little practice, it's not as bad as it sounds. In fact it is fun. Beekeepers have been using this method for over one hundred years to produce thousands and thousands of quality queens. Trust them, it works.

G. M. DOOLITTLE

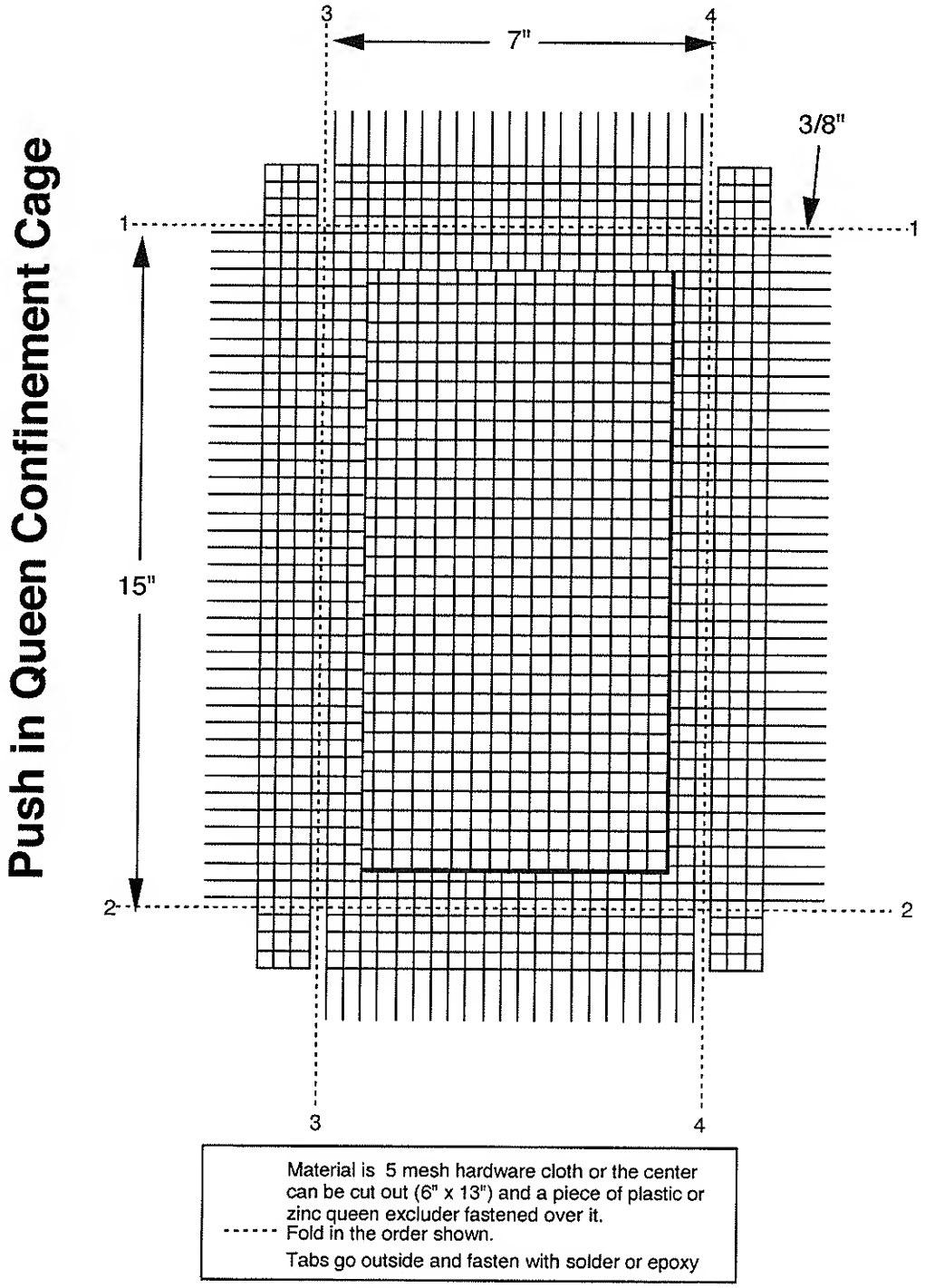
EQUIPMENT NEEDED FOR QUEEN REARING

Most of the equipment needed will be standard Langstroth equipment. However there are a number of things that will need to be custom made.

Queen Confinement Cage

- This is a cage built to enclose a single, deep brood frame or part of the frame. The breeder queen is confined 4 days before grafting to ensure the larvae are of the proper age for grafting. Three cage designs are as follows:
- A queen confinement cage can be made using queen excluder and sheet metal. The top, bottom and ends of the compartment are made of sheet metal. The sides are made from a queen excluder which is cut to size. The compartment is welded so that a deep frame fits inside. It can be made of wood if a nonstandard smaller frame is used.
- Two vertical dividers made of queen excluder can be arranged on either side of a frame. The dividers must be sealed on top with a piece of cloth or plastic, and must seal tight against the sides and bottom (including the rabbet) to prevent the queen from escaping.
- A push-in queen confinement cage made from hardware cloth is effective for one side of the frame. This can be made from 5x5 mesh (size used for pollen traps) or from 8x8 mesh with the center cut out and queen excluder material put over it (see drawing on page 23).

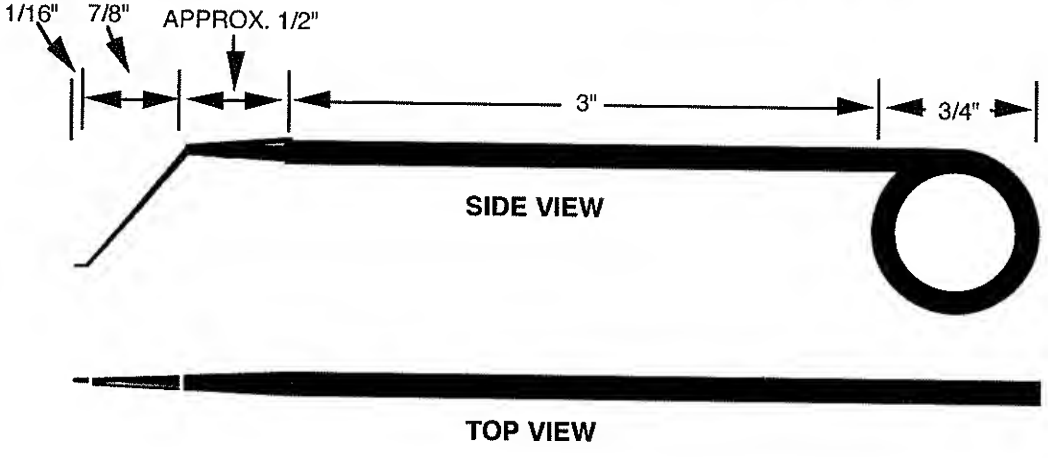
FIGURE 4.
Plans to make a push-in queen confinement cage



Grafting Tool

- This device is used to transfer the 12-24 hour old larvae from the frame to the queen cup. There are a wide variety of grafting tools available and the one you choose will be a matter of personal preference. Some of the more common types are listed here.
- The *Master grafting tool* is a metal spring device that is used to scoop up the larva and then to release it into the queen cup by retracting the spring. This tool is relatively expensive.
- The *Hook grafting tool* is a metal bent hook designed to scoop up the larvae and place it into the cell manually. Some hooks come with an attached magnifying glass.
- A *custom-made hook type grafting tool* can be hand-made by filing and bending a 12 gauge wire to the desired shape and angle (see drawing on page 25).
- The *Chinese grafting tool* is made in China with a thin piece of water buffalo tusk which is retractable to place the larvae into the cell.
- An *artist brush* size 00 with the bristles trimmed can be used to transfer larvae.
- A *toothpick* can be filed and softened with water to make a grafting tool.

GRAFTING TOOL



ACTUAL SIZE

To make this grafting needle start with an eight inch piece of 1/8" diameter (12 gauge) steel wire. Grind and or file the end as shown above. Finish with a fine file or emery paper so the end is smooth. Then bend the wire to the shape shown above. Note the rounded tip on the top view.

This shape and size is preferred by the authors. Do not be afraid to experiment with different angles or lengths that may fit your hand size or preferred grafting position. If you think you would like a thicker handle you can wrap it with string or cord or you can cut off the hook end and put it into a short piece of dowel rod.

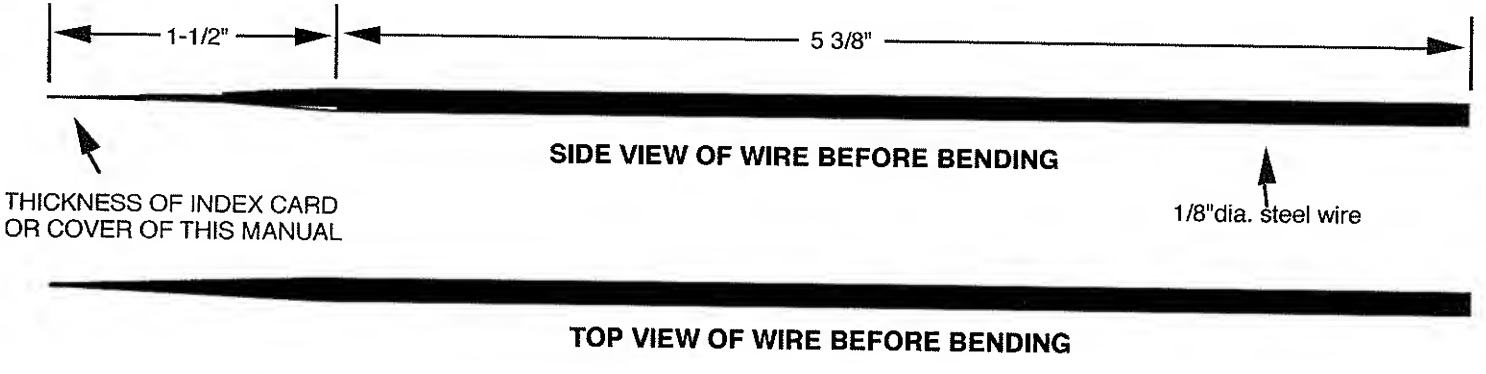


FIGURE 5.
Plans to make a custom grafting tool.

Queen Cups

- Queen cups are the cells into which you will graft the larvae that will be reared into queens.
- *Beeswax queen cups* can be purchased from a bee supply store, or hand made. To make them, first make a "dipping peg" by filing 3/8" diameter dowels (3" long) to the rounded shape of a queen cup (tapered to a diameter of 1/4-5/16" starting at a point 1/2" from the end to be rounded). The dowels can be used individually, or securely attach 15-20 pegs to a dipping peg board. Melt beeswax in a tray long enough to fit the peg board, and place the tray in a larger tray of water. Place the trays over a hot plate kept at a temperature just above the melting point of beeswax (143.6-147.2^{0}F). When this temperature is reached, a thin skin forms on the surface of the wax around the edge of the tray. Dip the pegs in a separate tray of soapy water for 5 minutes to prevent the wax from sticking to the pegs. Shake off the excess water, then dip the pegs into the melted beeswax 3/8" deep. Remove the pegs, let them cool, then dip them again a little shallower each time for a total of three times. Gently twist the cells to remove them from the pegs. Rinse the queen cups well in water to remove the soap residue. These queen cups can be stored in glass jars until needed. Wax cups should not be reused.
- *Plastic queen cups* also can be purchased. Plastic queen cups come in different colors which can be used to track queen lines or grafting dates. They are easily cleaned and can be reused. To clean them, take a dental tool or some other similar tool and gently scrape out the old cocoon and any wax. If it is warm and sunny, you can fill the cups with water and let them stand in the sun for a while until the cocoons and wax soften, then they can be easily cleaned. Before grafting, place a frame with attached queen cups in a colony so the worker bees can finish cleaning and polishing the cells. Worker bees will not feed and tend larvae that are grafted into dirty, dusty, or unpolished cells, so this step is very important.

Cell Bases

- The queen cups must be attached to a cell bar (see next item, below) using some kind of cell base. There are many ways to prepare cell bases; some are listed below.
- Paint melted beeswax on the cell bars, and attach the queen cups directly to the cell bar. This method is easy but inconvenient because the queen cells must be cut from the cell bars to remove them.
- Purchase wooden cell bases. The queen cups (purchased wax or plastic, or hand-dipped) fit into these wooden bases. The bases are then attached to cell bars using melted beeswax. Be sure to use sufficient wax to secure the bases firmly. The wooden bases can be gently twisted off the cell bar to remove the queen cells. They can be reused.
- Some of the newer plastic queen cups have pins or pegs ("Base mount cell cups") that wedge the queen cup into a grooved cell bar.

Cells Bars and Frames.

- The queen cups and cell bases are attached to cell bars, which then fit into standard frames as diagrammed on page 29.
- The cell bars are a simple stick of wood to hold the cell cups. A bottom bar from a frame works fine. 15-20 cell cups are centered on a cell bar at a time.
- The frame is designed to hold three cell bars. A standard frame can be adapted for this use (See drawing on page 29).
- It is an excellent idea to staple a small (3-4") strip of aluminum flashing on the top of the cell bar and frame. You can write on the flashing with a permanent marker. This way, you can record the queen line and date the cells were grafted (or the date they are due to emerge) directly on the cell bar and frame to avoid any confusion. The writing is easily erased with sand paper or rubbing alcohol to prepare the cell bar or frame for the next graft.

Swarm box

- This is the most difficult piece of equipment you will need to make or obtain. A swarm box is basically a 5 frame nuc box made extra deep with screened vent holes on the sides and bottom. It will hold 5 standard size deep frames leaving 4-6 inches under the frames for ventilation and placement of moist sponges which provide humidity and water. The cover must be bee tight and slide on easily without killing any bees. For construction details, see the drawing on page 30.

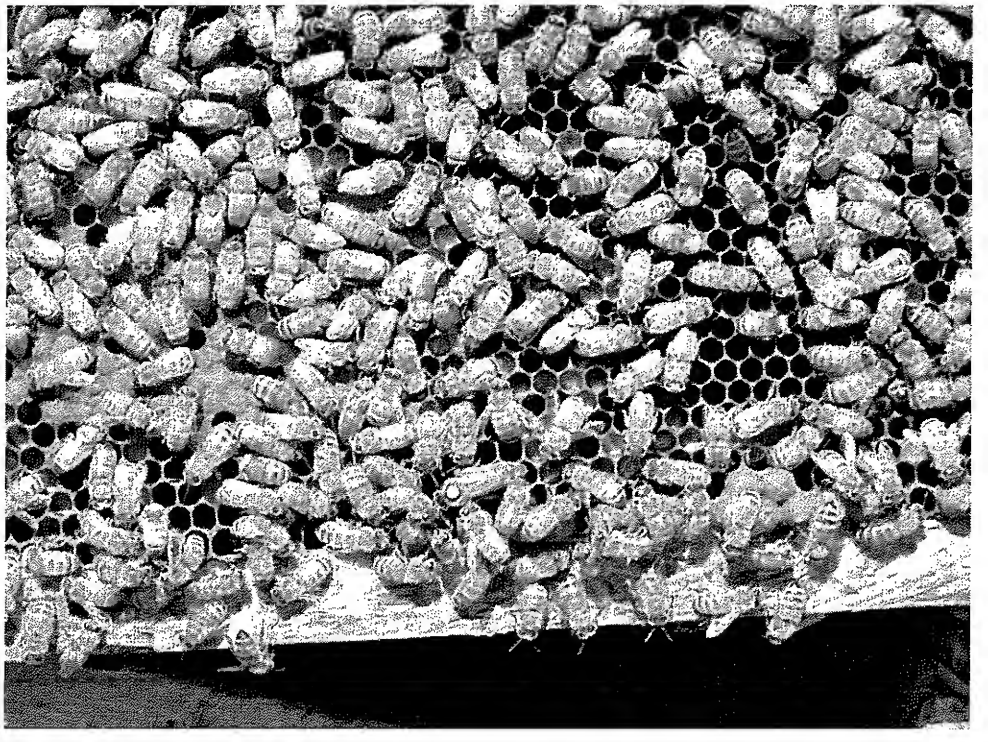
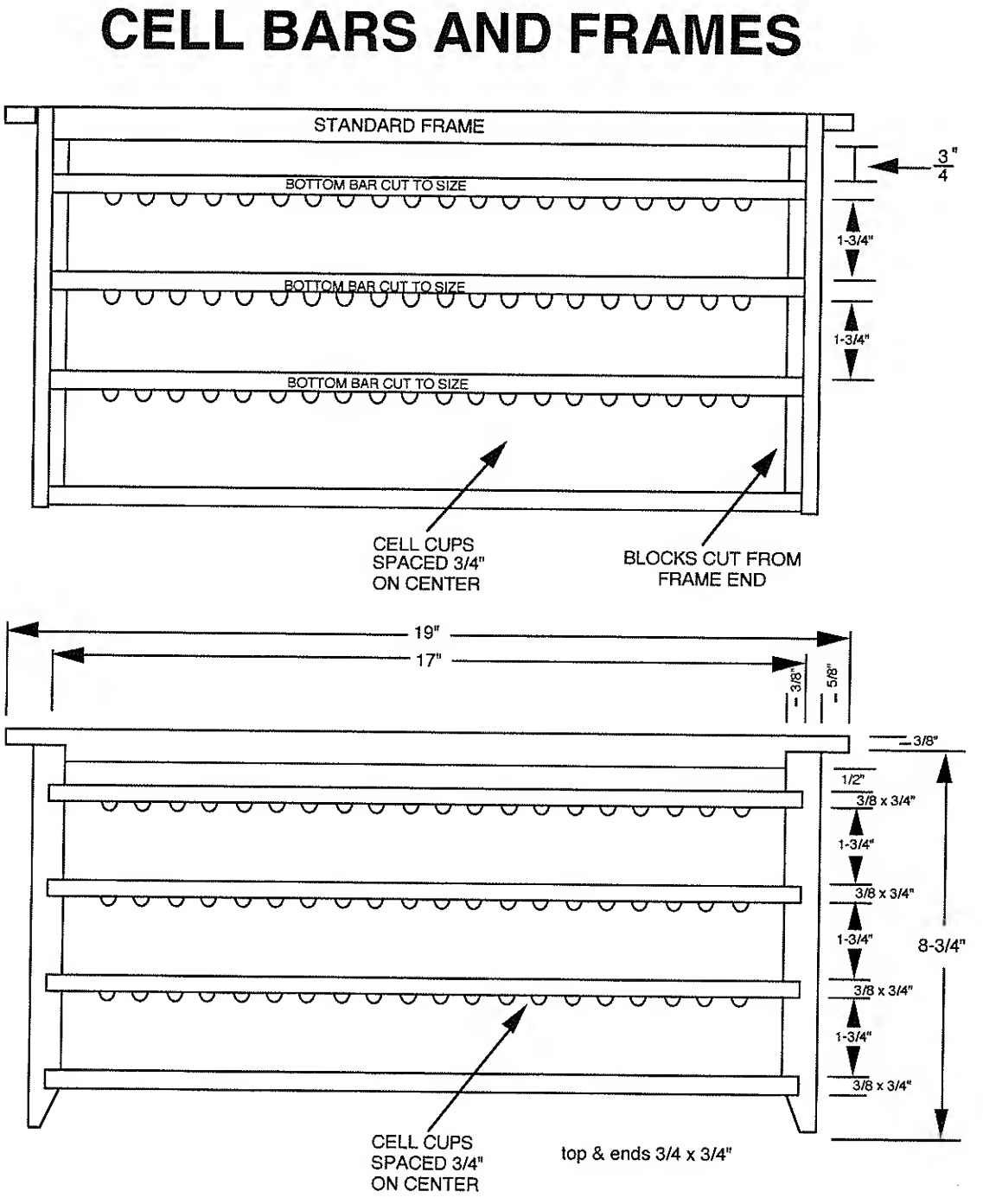


FIGURE 6.
Two methods to construct cell bars and frames for grafting into cell cups.



9 - 1" = 4"

Swarm Box 1 of 2

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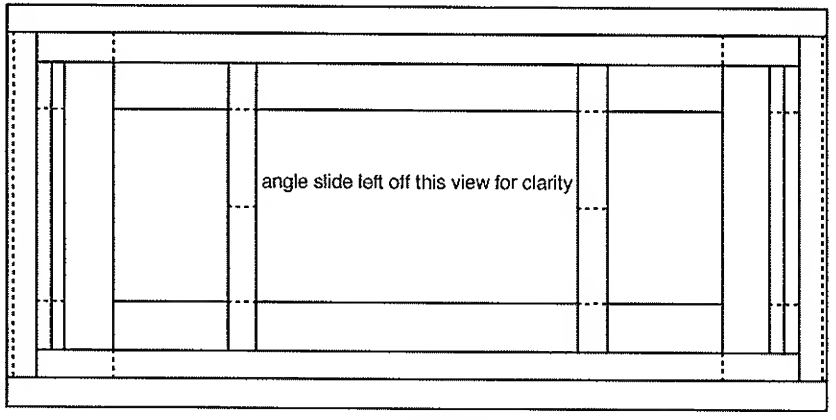
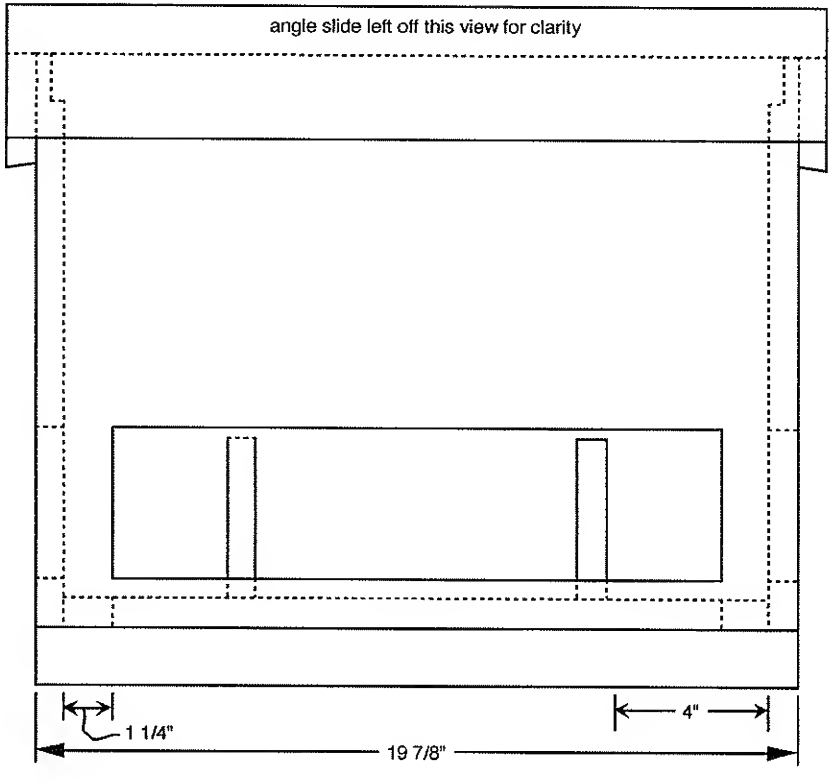
University of Minnesota
Dept. of Entomology
07-28-06

Openings on the sides, ends & bottom are covered with 8x8 hardware cloth on the inside.





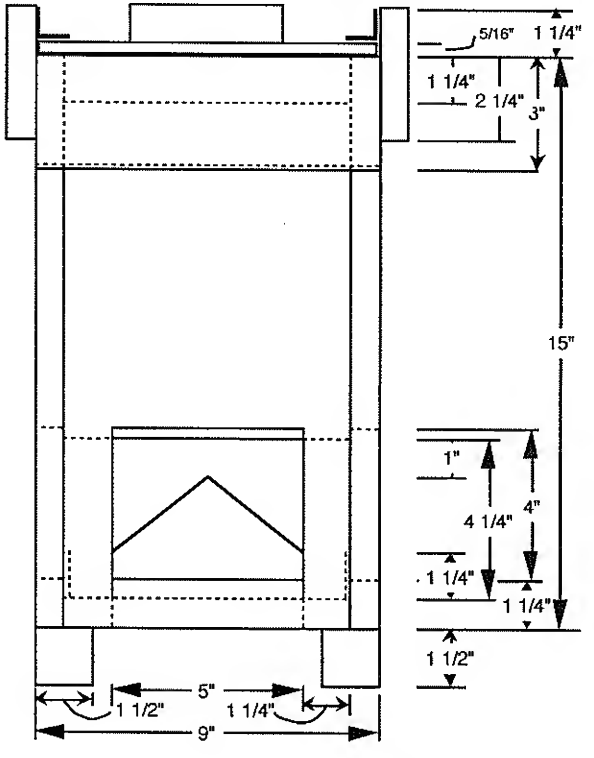


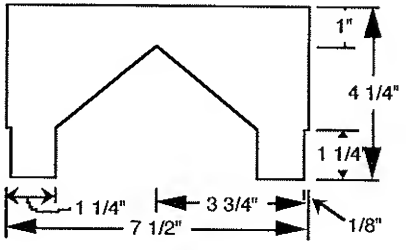
FIGURE 7A.
Plans to build swarm box.

Swarm Box 2 of 2

Drawn by Gary S. Reuter
University of Minnesota
Dept. of Entomology
07-28-06

FIGURE 7B.
Plans to build swarm box

Frame support detail
3/4" pine or plywood



Material List

3/4" #2 Pine or plywood
2 - 7-1/2 x 15 = ends
2 - 15 x 19-7/8 = sides
2 - 1-1/4 x 15-7/8 = bottom
2 - 1-1/4 x 7-1/2 = bottom
2 - 3-1/2 x 21-3/8 = bottom
2 - 3 x 9 = handles
2 - 1 x 3 = cover handle
2 - 4-1/4 x 7-1/2 = frame supports

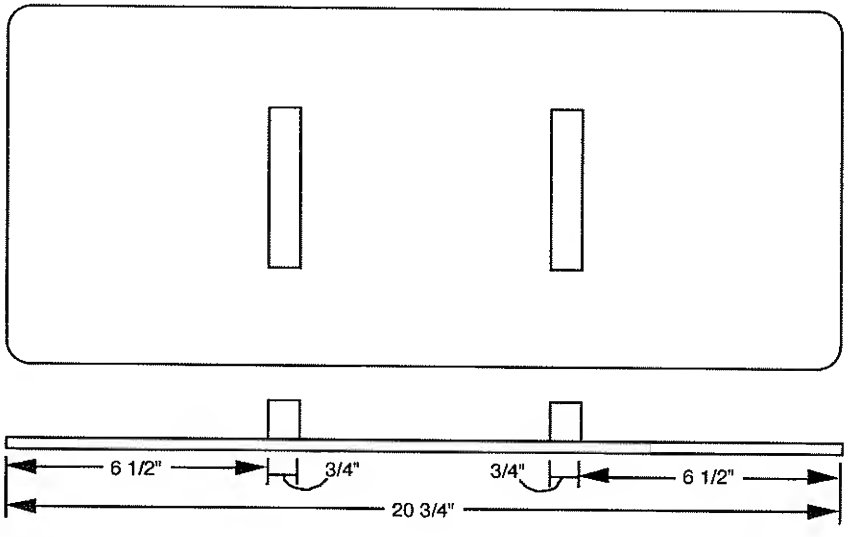
1-1/2 x 1-1/2 FIR
2 - 19-7/8 = legs

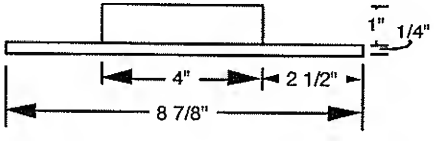
Tempered Hardboard
1 - 1/4" x 8-7/8 x 20-3/4 = cover

Hardware Cloth 8x8
1 - 18 x 18-1/2 = bottom & sides
2 - 5-1/2 x 7 = ends

Misc.
2 - 3/4 x 3/4 x 20" angle metal

Cover





Incubator (optional)

- Some people prefer to remove the queen cells from the finishing colony a day or two before they are due to emerge and place them in an incubator until they are ready to introduce the cells into mating nucs, or until the queens emerge. This procedure is optional. The cells are usually removed from the finishing colony and introduced directly into mating nucs without incubation.
- The best incubator for a small number of cells is a still-air incubator designed for hatching chicken eggs. They are made of Styrofoam and contain a heater and thermostat. The temperature must be kept between 92-94°F. Queens will die at temperatures above 96°F and below 88°F. Water should be provided in the incubator to maintain the relative humidity at 70-80°.
- If you are going to incubate queens, you will need individual glass vials or screened cages to support the cells in a vertical position in the incubator. Any vial or cage that the cell fits into will be adequate. The wooden cell bases come in handy here because they double as a lid for the vial.

Mating Nuc(s) (optional) (see drawings on pages 40-48)

- A mating nuc is a small colony set up to house the queen during her mating period. The mated queen will begin laying eggs in the nuc and can be removed when needed. She can then be introduced into a larger colony or sold.
- For a limited number of queens, single divides can be made and used as mating nucs. In this case, the mated queens may be left in the divides to begin a new colony.
- A standard hive body can be divided into 4 sections with 1/4" boards placed in the direction of the frames. Separate entrances should be provided by drilling a 1" hole into each compartment so that the entrances for the middle two compartments lead out the front and back of the hive, and the entrances for the end compartments lead out opposite sides. It is also a good idea to paint designs around each entrance hole a different color to help the virgin queens orient to their compartment when they return from their

mating flight. Each section is then filled with 2 frames containing bees, brood and honey. A queen cell is introduced by gently but firmly pressing it between two frames. The top should be covered with plastic or canvas and cut such that only one compartment is opened at a time.

- A 3 frame mini-nuc can be made which contains 1/2 size medium frames. See plans on pages 40 to 45. These are a good size for mating and make finding the queen much easier.
- A feeder must be supplied to all nucs because they contain a small number of bees and will need sugar syrup. Bees accept a new queen more readily when they are fed.

Introduction cages (optional)

- If sealed queen cells are introduced into a queenless colony (divide, or mating nuc) introduction cages will not be needed. However, if the queens are allowed to emerge in an incubator and virgin queens are introduced into colonies, introduction cages will be needed. Be aware that the bees will more readily accept a queen cell than a virgin queen. However, in some instances, it is desirable to introduce virgin queens. The cages described below work equally well to introduce virgin and mated queens.
- *Three-hole wood cages* are the most common cages used to introduce queens. You may have these available from queens you have purchased in the past. After cleaning them and placing new queen candy in them, they can be used in the standard way so the queen releases herself after the queen candy is chewed away.
- *Sleeve introduction cages* are made from 8x8 hardware cloth, shaped into a rectangular "sleeve" 3/8 x 3/4 x 4-1/2" (see drawing on page 35). One end is fitted with a plug (or is welded) and the other end is fitted with a removable plug (such as a block of wood whittled to fit the cage). A caged queen may be placed between the frames. You must return in 3 days to release her. The advantage of releasing queens yourself is that you can monitor her acceptance by the response of the bees toward her as she is released. The disadvantage is that you have to return in 3 days. This

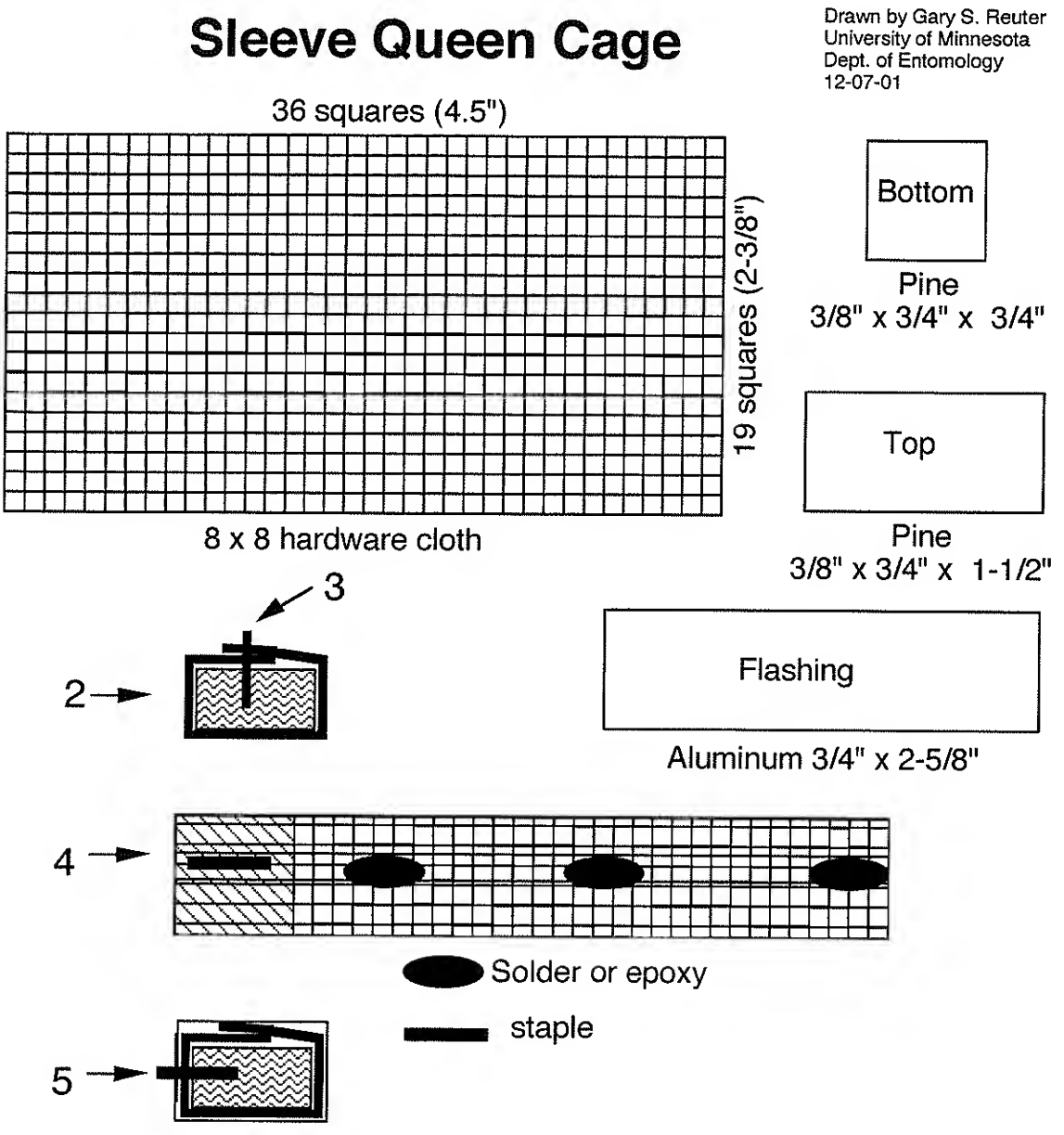
system works well for hobby beekeepers but not for commercial beekeepers, unless the queen to be released is extremely valuable.

- *Push-in cages* are made from 8x8 hardware cloth, shaped into an open box 3" wide x 5" long and 3/4" deep. The bottom 3/8" squares of the hardware cloth are cut open to make pins that push into the comb (see diagram, page 39). The queen is put under the cage over emerging brood. This allows her to be tended by new bees and begin laying (if she is a mated queen) before she is released. With this system you must return to release the queen. This is the preferred method to introduce instrumentally inseminated queens or other queens that are valuable to you. The advantage is that queens are more readily accepted if they are allowed to lay some eggs before they are released.

Queen Candy

- Queen candy is used to plug the third hole of a queen cage to provide food and allow slow release of the queen.
- Queen candy can be made with powdered sugar mixed with corn syrup to a soft but firm consistency. If the candy is too moist, it will run when warm and not serve its purpose as a plug. If it is too hard, it will serve as permanent plug, and the queen will not be able to release herself.
- A piece if wax paper should be placed between the candy and the screen to prevent the candy from drying out.

FIGURE 8.
Plans to build sleeve queen cage.



1. Cut pieces as shown above.
2. Roll cloth around 3/8"x 3/4" x 8" stick as shown. Try to bend corners tight so it will keep its shape.
3. Remove from stick. Put bottom in lower end and staple where the ends overlap.
4. Hold the screen so it keeps the proper form and solder or epoxy at least 3 places along the seam on the side.
5. Wrap flashing around the bottom end as shown and staple at the overlap.
6. Wittle the corners of the top so it fits snug.

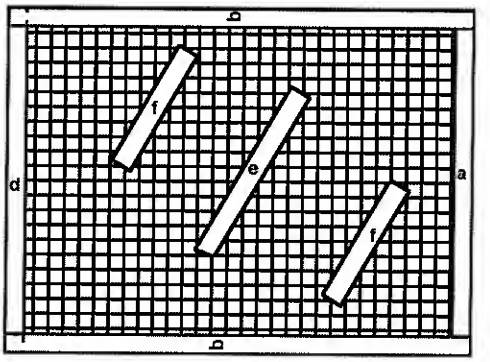
Pollen Trapping

- Pollen traps are designed to force the bees to crawl through an entrance screen or hole in such a way that part of the pollen load they are bringing into the colony will be knocked off of the pollen baskets on their hind legs and will fall into a drawer. The pollen can then be used to feed the bees when natural pollen is not available.
- Pollen should be trapped from strong colonies that have a large population of bees and sufficient pollen reserves so that removing some incoming pollen does not hinder the colony.
- Pollen should be trapped when there is a large "pollen flow."
- Pollen should be collected at least every 2-3 days to prevent it from molding in the trap. It should be frozen as soon as possible to preserve the needed nutrients.
- Pollen trapping should be done for one to two weeks from one colony then stopped for a week or more before trapping for another period of time. Some trap designs allow for the trap to be left on the hive but adjusted so the bees can enter the hive directly without passing through the screen.
- There are many pollen trap designs, some have front drawers, some back drawers. They can be purchased or made.

FIGURE 9A.
Plans to build pollen trap, Part 1

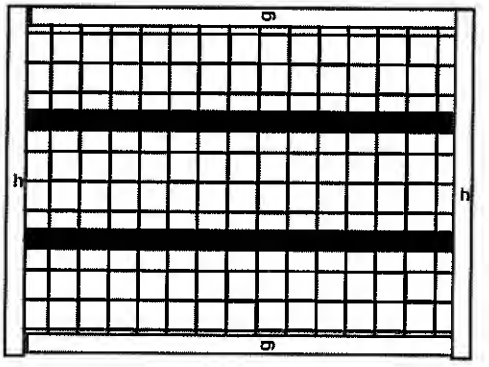
POLLEN TRAP

a - 1 - 3/4 x 3/4 x 11-1/2"
b - 2 - 3/4 x 3/4 x 17-3/8"
c - 1 - 8x8 mesh 17 x 12-3/4"
d - 1 - 3/8 x 3/4 x 13"
e - 1 - 3/4 x 3/4 x 7"
f - 2 - 3/4 x 3/4 x 5"



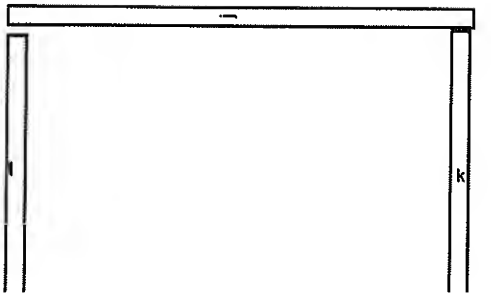
Nail corners a & b then staple on screen then nail on part c and staple screen to c, d, e & f.

g - 4 - 1/4 x 3/4 x 15-7/8"
h - 2 - 1/4 x 3/4 x 13"
i - 2 - 5x5 mesh 17 x 12-3/4"



staple mesh to both sides then nail to section above

j - 2 - 3/8 x 3/4 x 17-3/8"
k - 1 - 3/8 x 3/4 x 11-1/2"
l - 1 - 3/8 x 3/4 x 11"



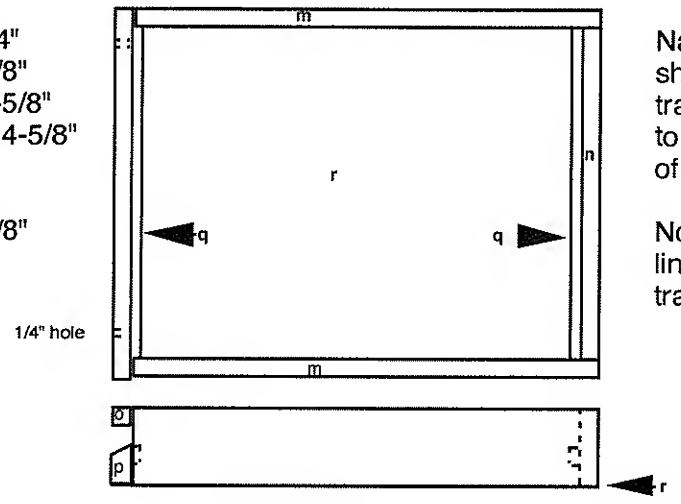
Nail to section above as shown. Note 1/4" space on each side of l to allow drones to escape.

This completes the trap portion. This trap will set into the drawer below.

FIGURE 9B.
Plans to build pollen trap, Part 2

POLLEN TRAP

m - 2 - 3/4 x 3 x 18-1/4"
n - 1 - 3/4 x 3 x 13-1/8"
o - 1 - 3/4 x 3/4 x 14-5/8"
p - 1 - 3/4 x 1-1/2 x 14-5/8"
(30 deg bevel)
q -2 - 3/8 x 3/4 x 13"
r -1 - 1/8 x 19 x 14-5/8"

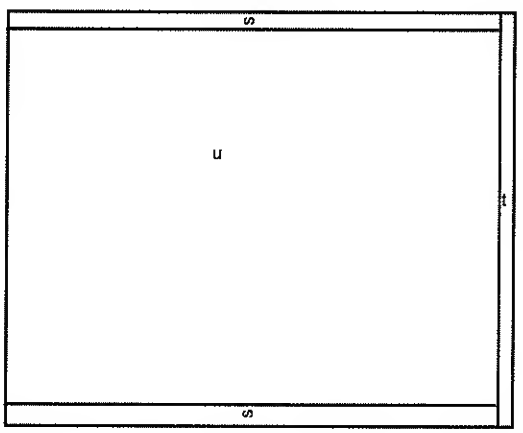


drawer

Nail drawer together as shown. Pieces q support trap and should be placed to hold trap flush with top of drawer.

Note 1/4" hole in part o lined up with slot in pollen trap for drone escape.

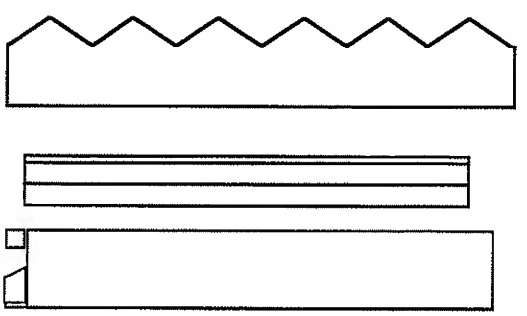
s - 2 - 3/4 x 3-1/4 x 19-1/8"
t - 1 - 3/4 x 3-1/4 x 16-1/4"
u - 1 - 1/8 x 16-1/4 x 19-7/8"



base

Nail base as shown the above drawer will slide into this with the hive setting on top of it.

Final Assembly



Bottom hive body of colony

Pollen trap

Drawer

FIGURE 10.
Plans to build push-in queen introduction cage.

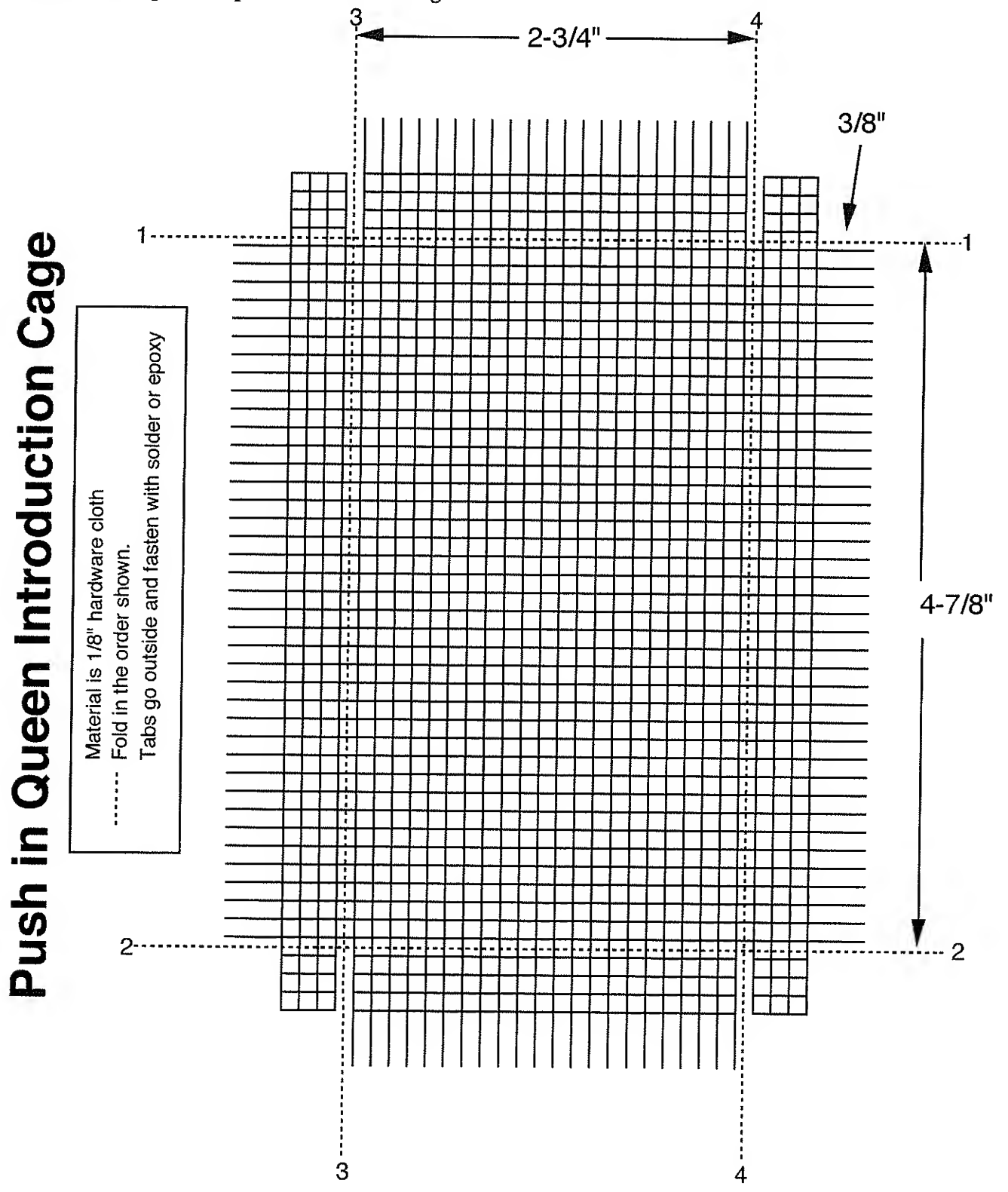
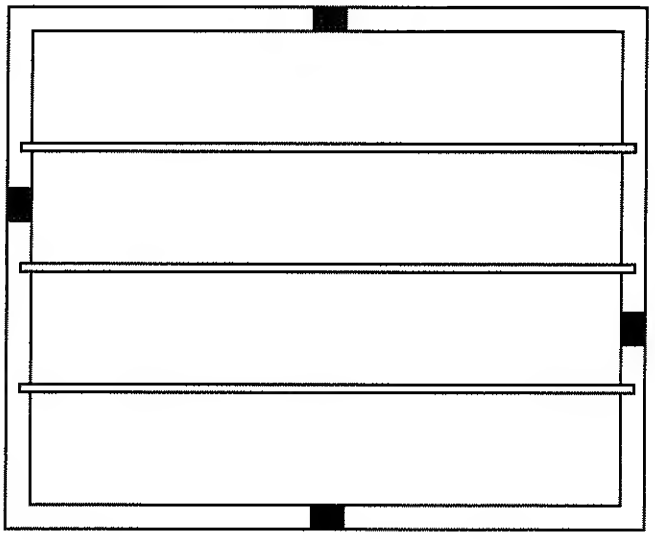


FIGURE 11.
Plans to build mating nuc from standard hive body.

Hive Body Mating Nuc



Standard hive body with depth to match frames. One inch holes centered as shown. Space between dividers = 3.5". The bottom board entrance should be sealed with a solid entrance reducer or entrance reducer wrapped in tin foil. Inner cover should be used to open only one section at a time. Plastic window shade or unbleached muslin works well as an inner cover.

Be sure the dividers go all the way to the bottom board and the rabbets on top are plugged at the dividers.

FIGURE 12.
Plans to build 3 frame mini mating nuc.

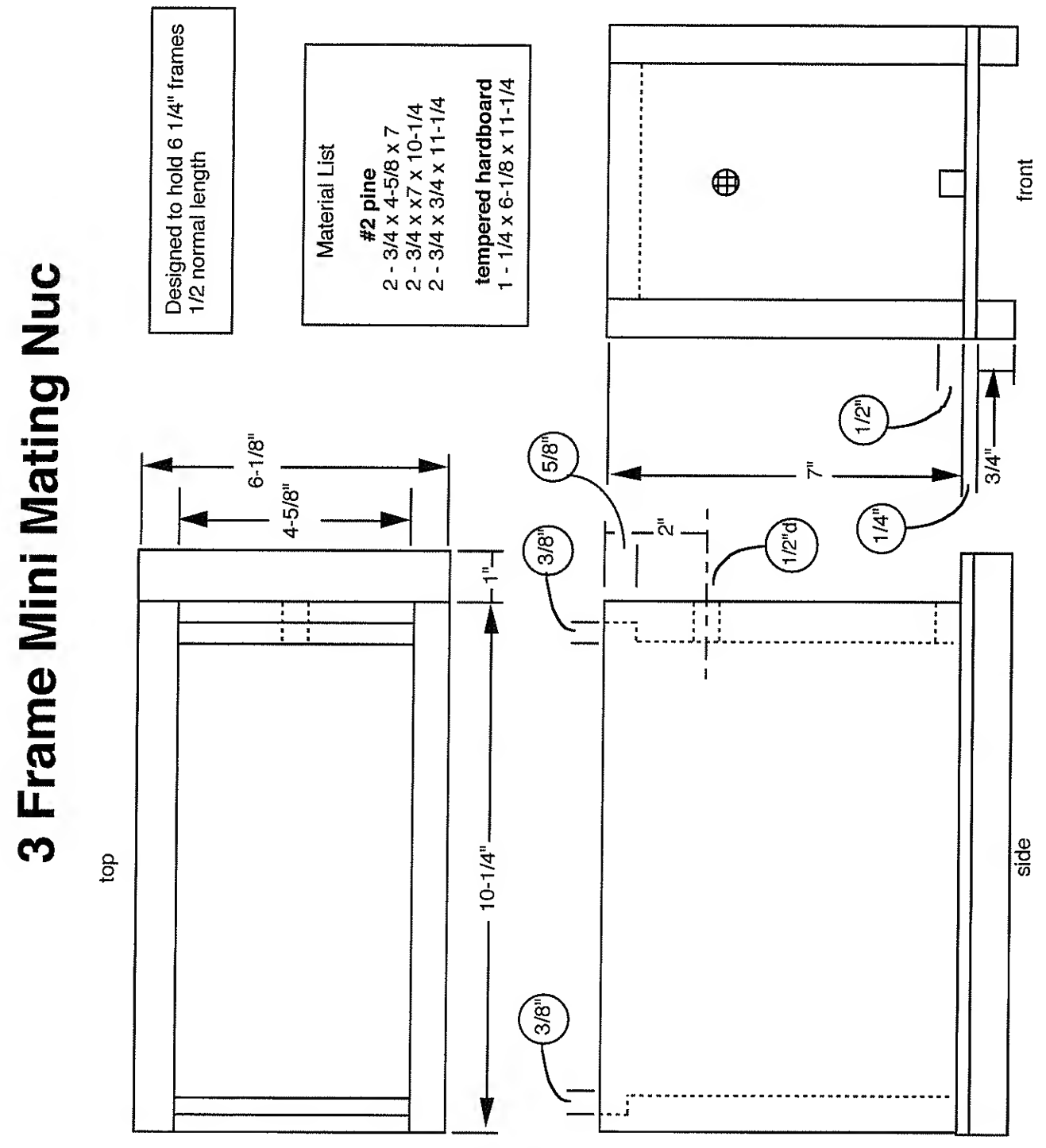


FIGURE 13.
Plans to build 4 frame mini mating nuc.

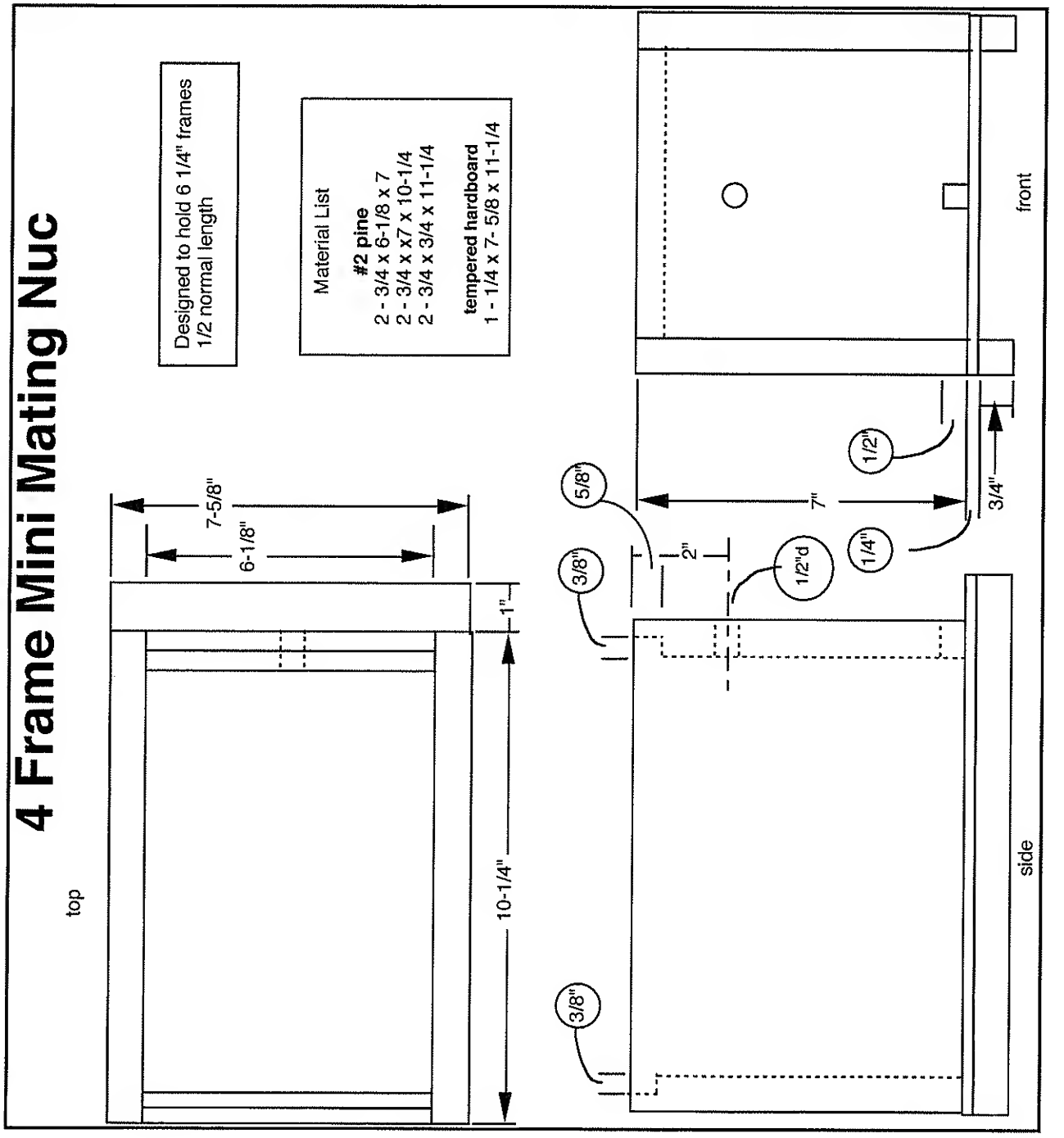


FIGURE 14.
Plans to build cover for 3 or 4 frame mini mating nuc.

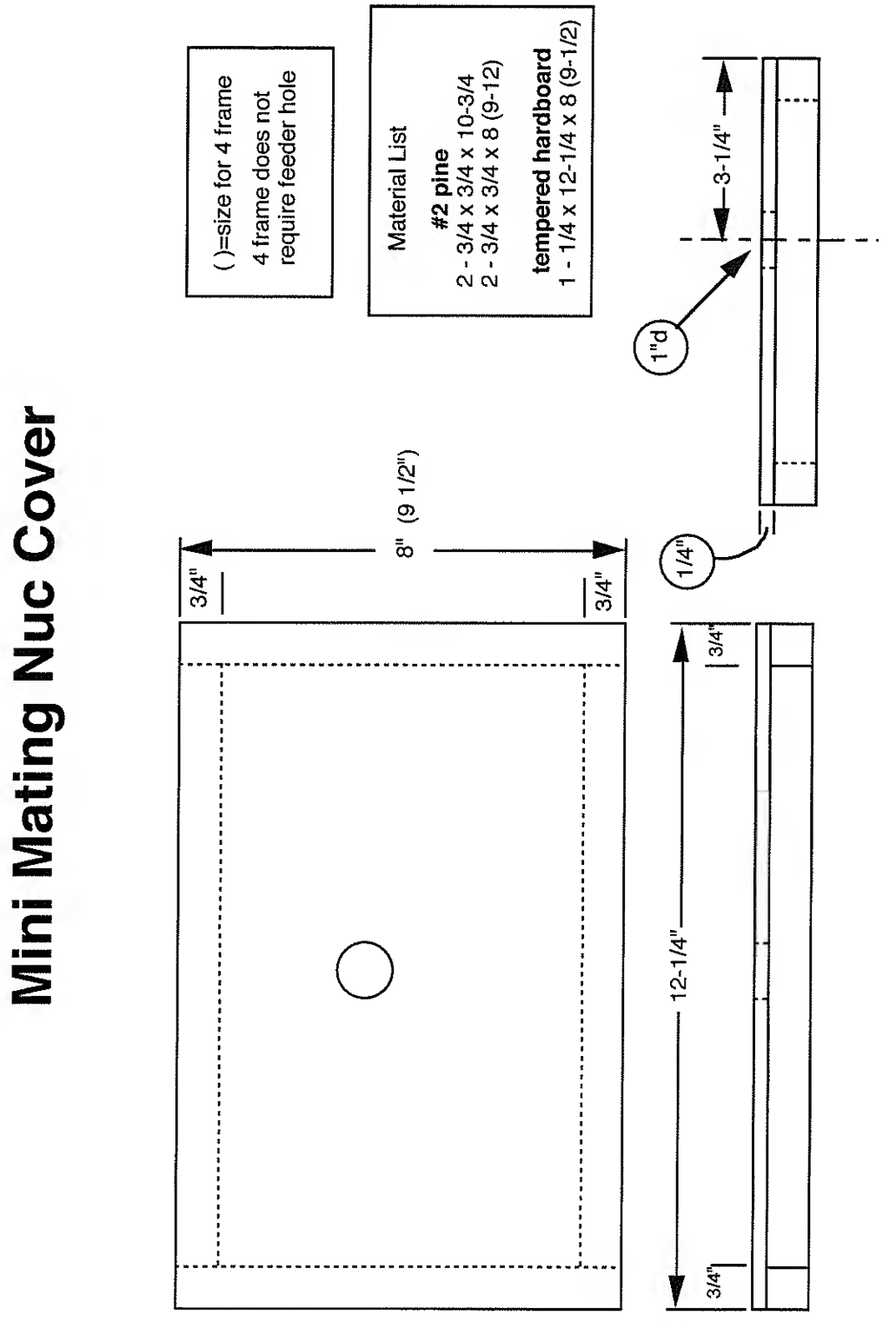


FIGURE 15.
Plans to build mini mating nuc feeder.

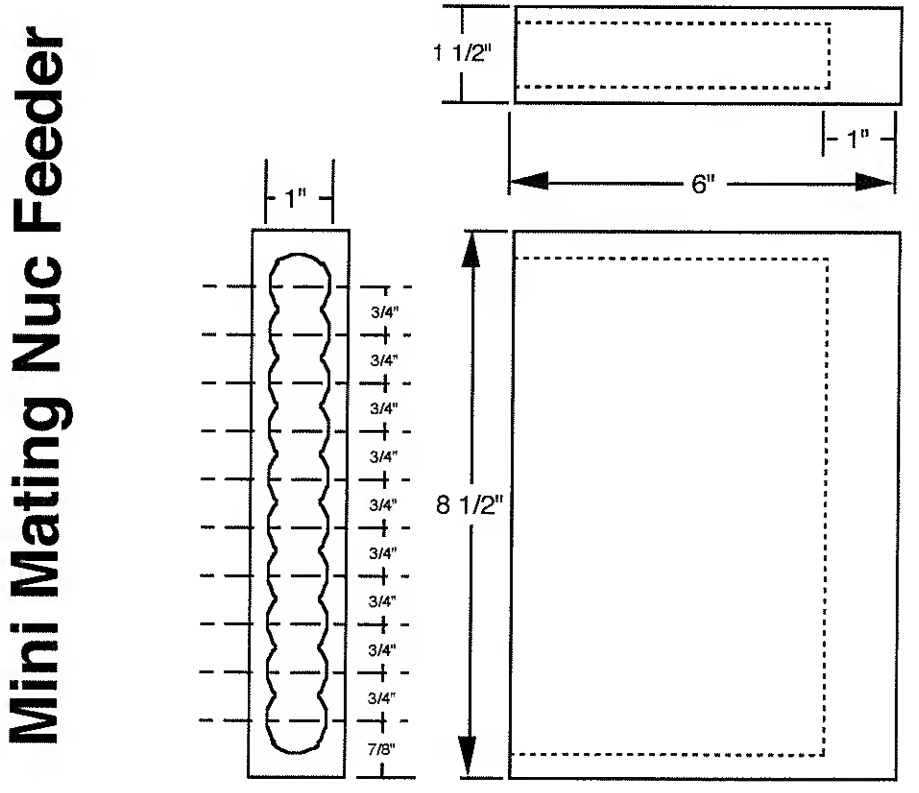


FIGURE 16.
Plans to build 3 frame mini mating nuc with feeder.

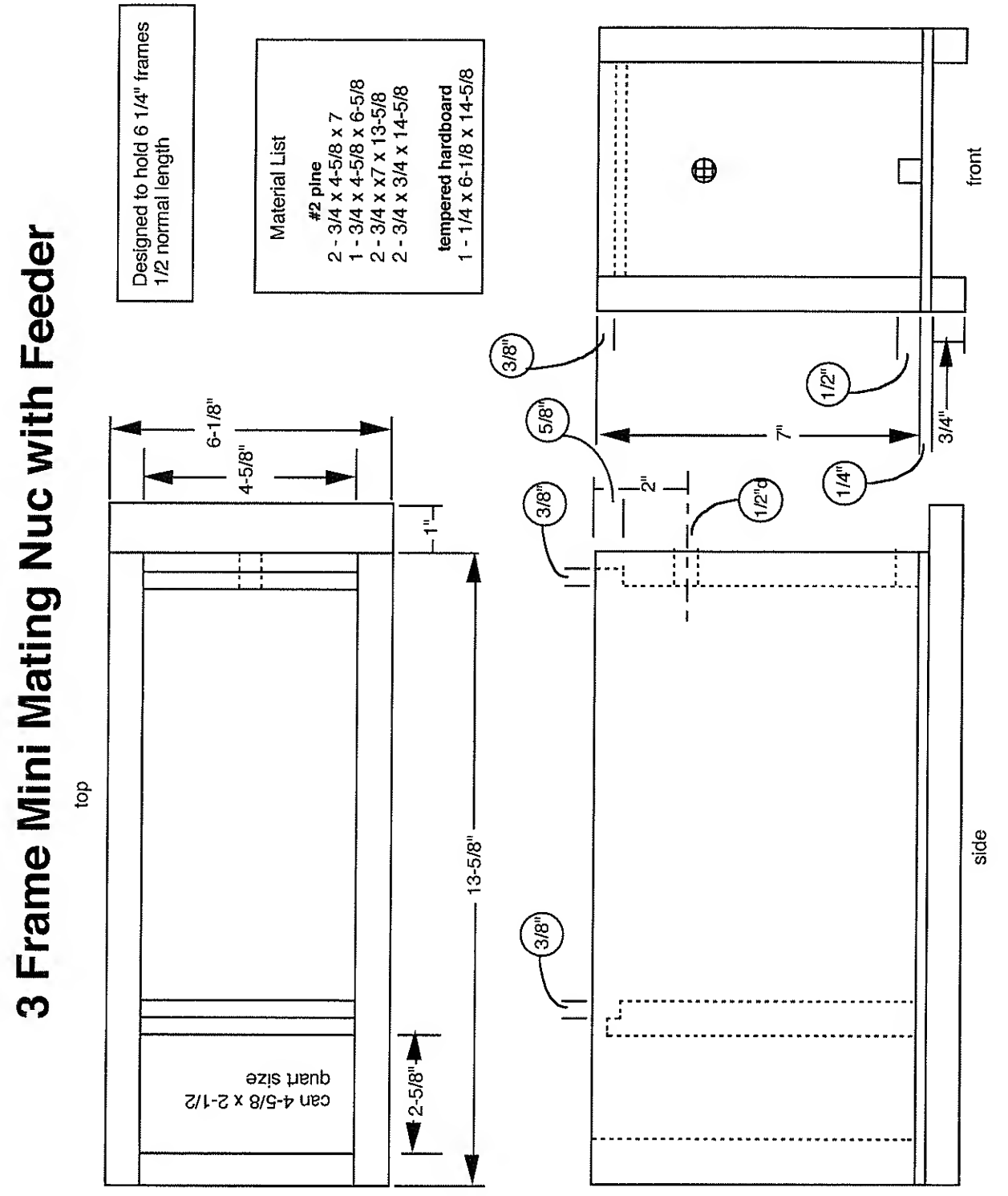


FIGURE 17.
Plans to build cover for 3 frame mini mating nuc with feeder.

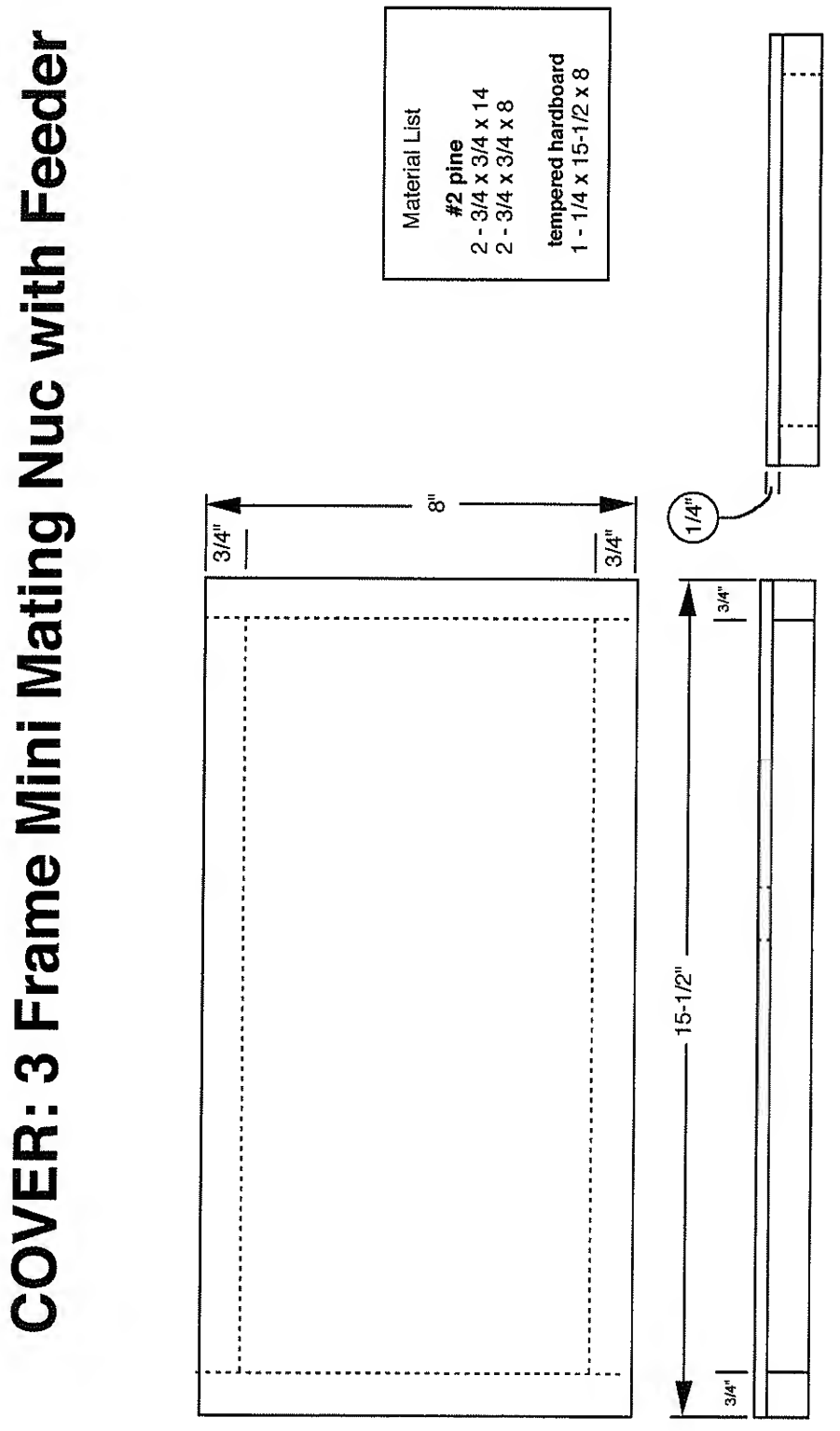
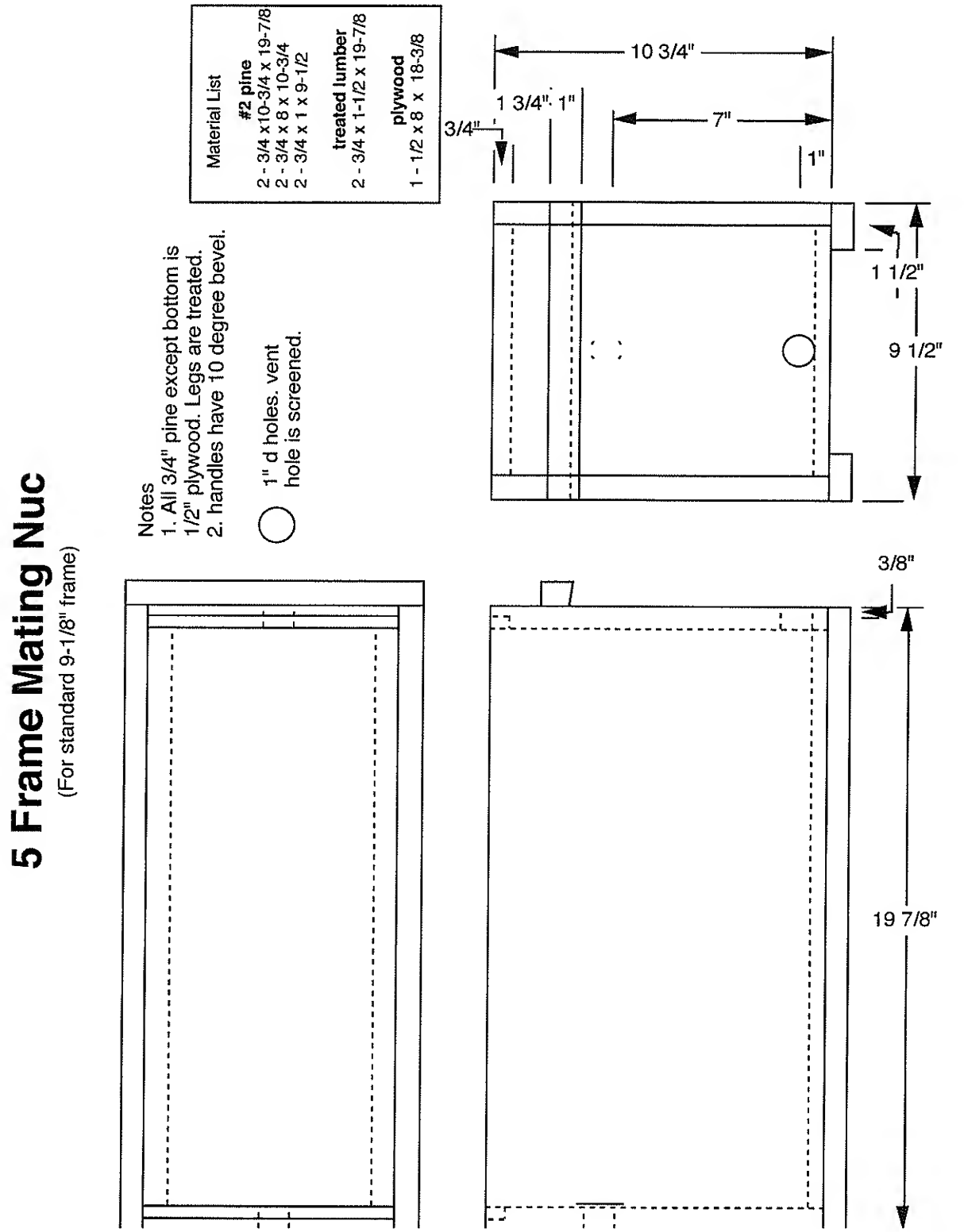
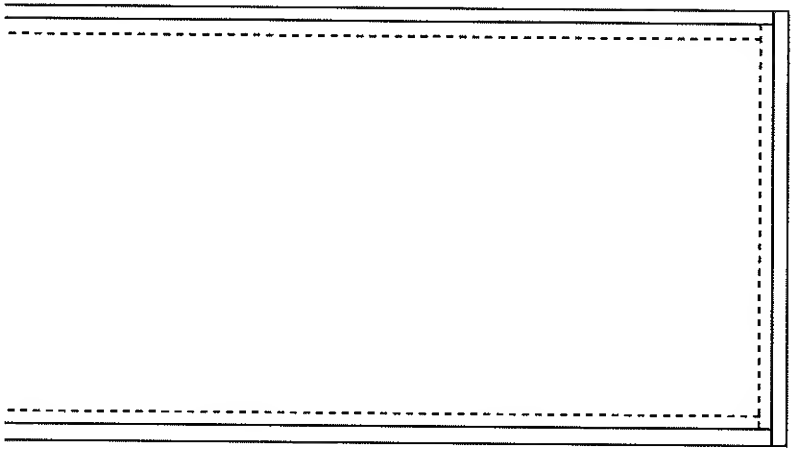


FIGURE 18.
Plans to build 5 frame mating nuc.



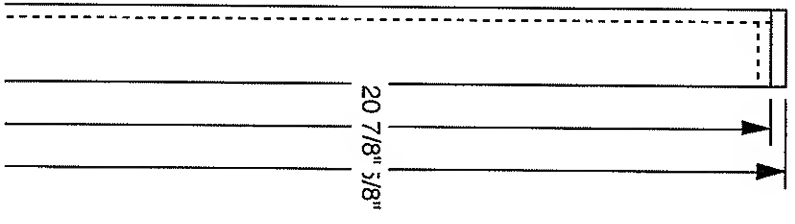
5 Frame Mating Nuc Cover

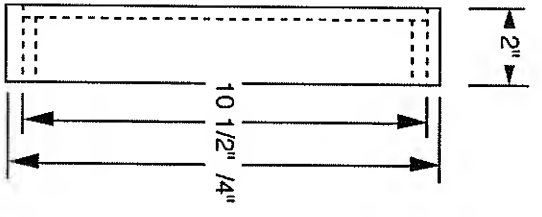
Drawn by Gary S. Reuter
University of Minnesota
Dept. of Entomology
02-03-06



Notes
1. All 3/4" pine except Top is 3/8" plywood.
2. Top and 1/2" down all sides is covered with aluminum flashing. (not shown)
3. Rabbets are 3/8" x 3/8"
4. Top plywood sets into rabbets
5. Typical corner joint

6. Optional hardwood inner cover
   1/8 x 9-1/2 x 19-3/4"





Material List	#2 pine	plywood	hardwood
	2 - 3/4 x 2 x 11-1/4 2 - 3/4 x 2 x 20-7/8	1 - 3/8 x 10-1/2 x 20-7/8	1 - 1/8 x 9-1/2 x 19-3/4 (optional)

FIGURE 19.
Plans to build cover for 5 frame mating nuc.

THE DOOLITTLE METHOD OF QUEEN REARING - IN DETAIL

Preparing Breeder and Drone Mother Colonies

- Three weeks before you want to begin rearing queens you must make sure that your breeder colonies are populous and well-fed, have large amounts of pollen, are disease-free, and the queens have solid brood patterns.
- If you are using drone mother colonies, they must also be populous and disease-free. They MUST be supplied with pollen patties (prepared with real pollen if possible) or frames containing pollen and drone comb to stimulate them to rear drones. Pay attention to the queen rearing time table (pages 72 & 73) to ensure that mature drones will be available when the queens are ready to mate.
- Three weeks before you begin rearing queens, select large, populous colonies to become the finishing colonies. They MUST be disease-free. Provide them with pollen supplement and sugar syrup if nectar and pollen are not available.

THE FINISHING COLONY

A minimum of 9-10 days before you are ready to rear queens, you should set up a finishing colony (or colonies). If you do not have a sufficiently large colony, you should combine two colonies (remove one of the queens). Give the colony supplemental feedings of sugar syrup and pollen to stimulate it to rear more brood.

The finishing colony is a strong, populous, queen right colony. The finishing colony "finishes" rearing the queen cells after the swarm box has "started" them for 24 hours. To obtain good quality queens, the finishing colony must tend to the queen cells continuously. To accomplish this, the finishing colony is set up so that young nurse bees are drawn to the queen cells by placing frames of young larvae next to them. The queen is confined to the hive body below the queen cells by a queen excluder. The brood chamber consists of 3-4 deep hive bodies. This manipulation of the finishing colony has the effect of priming the colony to rear queens. It gets the bees "in the mood." It also provides the queen with ample space to lay eggs which boosts the colony population and morale.

The finishing colony should always be on the verge of swarming, and therefore be ready and willing to rear queens. You will not let it swarm, however, because you will perform routine manipulations on this colony every 9-10 days which prevent it from swarming.

You will have to work out a precise schedule for working the finishing colony so it coincides with when you want to graft.

Setting Up a Finishing Colony

1. Locate the queen in the colony and temporarily place her in a cage. Place the cage on the top of the frames of one of the boxes. If it is cool keep the cage in your pocket. Keep track of where you put the cage.
2. Go through each frame within the 3-4 boxes of the brood chamber and arrange them as shown in the diagram on page 52 or 53.
3. The bottom box will be filled as much as possible with honey and/or nectar and pollen. Bees prefer to have honey above the brood, so putting the honey on the bottom forces them to move it up which serves as a stimulatory feeder.
4. The second box should contain frames with empty cells and brood that is just about to emerge. (Gently uncap a few sealed cells and check them. If they have dark coloration, the pupae will be emerging within a day or so. If they are still white, they aren't "done yet.") Two to three frames containing honey, nectar and pollen are placed toward the edges of the box. The queen is released from the cage and placed within the second box where she has plenty of space to lay eggs.
5. A queen excluder is placed over the second box to confine the queen to the bottom two boxes.
6. The grafted queen cells will be placed in the third box and will be "finished" there. The third box should contain only 8 frames so there is room to place a frame with cell bars. The center frames in this box should contain eggs, very young larvae, and lots of stored pollen. Frames containing older larvae should be placed away from the center, and frames containing honey, nectar and pollen should be placed toward the edges of the box.
7. A fourth brood box is used if you plan to rear more than one batch of queens, or if you have more brood than will fit into three boxes arranged this way. The fourth box should contain older larvae and sealed brood, with frames of honey, nectar and pollen toward the edges. The sealed brood will consist of pupae that are still white and are not within a few days of emerging.
8. Honey supers can be added as needed.

FIGURE 20.
Proper placement of frames for use as a 3-deep finishing colony.

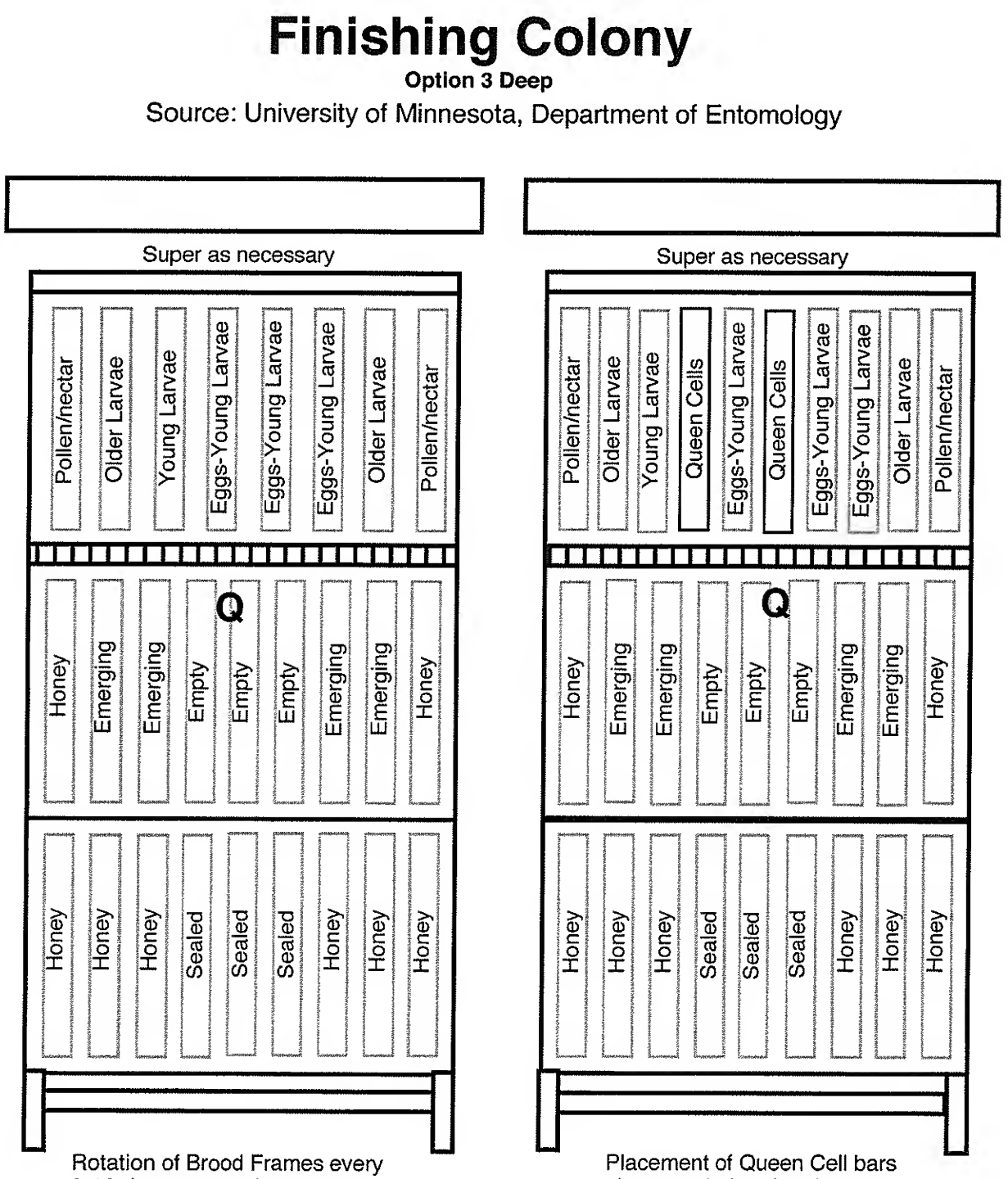
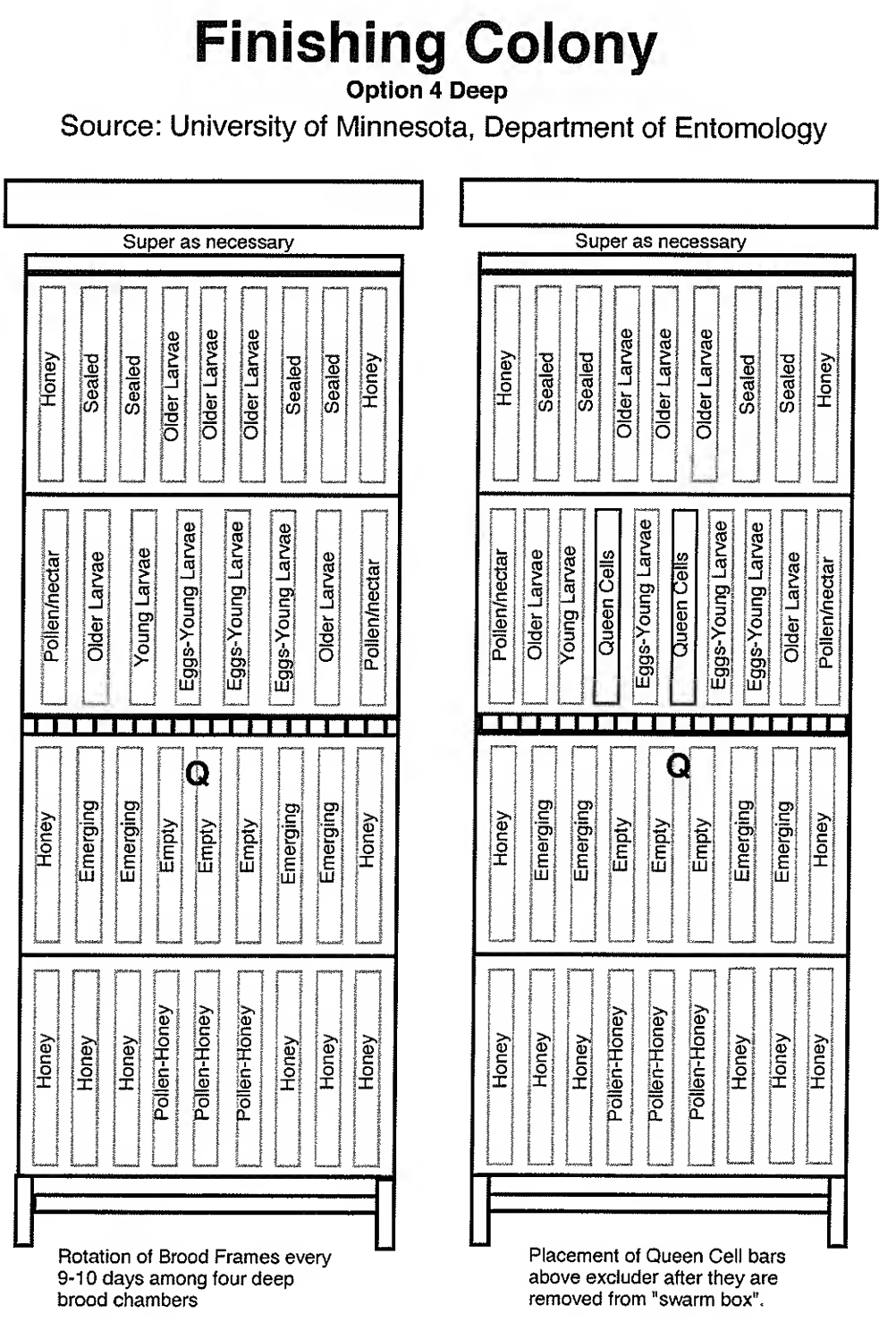


FIGURE 21.
Proper placement of frames for use as a 4-deep finishing colony.



Routine Maintenance of the Finishing Colony, or "Working" the Finishing Colony

- The brood in the finishing colony should be rotated EVERY 7-10 DAYS during the time you are rearing queens. If you plan to rear just one batch of queens, set up the finishing colony 7-10 days ahead of time and rotate the brood one more time the day before you graft.
- There are several reasons for routinely rotating the brood in the finishing colony:
    1. The queen will always have ample comb space in which to lay eggs.
    2. You will inspect every frame every 7-10 days so you can destroy any natural queen cells the bees build. If your finishing colony is functioning properly, the bees WILL build queen cells, particularly in the third box. This is a good sign because it shows they "want" to rear queens, but you need to make sure you destroy ALL natural queen cells and only allow the bees to rear the queen cells you provide them. There is nothing more disappointing than having a surprise virgin queen destroy all of your and the bees' work.
    3. You will constantly have a large supply of young bees above the excluder, which is necessary for finishing quality queen cells.
- You will have to work out a precise schedule for working the finishing colony so it coincides with when you want to graft.

PREPARING FOR GRAFTING

- Five days before you graft, place an empty, dark brood frame in the center of the brood nest of the breeder colony. This will allow the bees to clean the cells out while it obtains the odor of the colony. Confine the brood frame within a queen confinement cage so the queen cannot lay eggs on the frame.
- The next day, or four days before you graft, place the breeder queen within the queen confinement cage to allow her to lay eggs. You will be rearing queens from these eggs, so make sure the colony is large and takes good care of these eggs. Place frames containing pollen on either side of the queen confinement cage so there is adequate protein to feed the larvae when they hatch.
- Within the next day or so, check the brood frame to be sure the queen has laid eggs. If the frame is full of eggs on both sides, remove the queen from the queen confinement cage but leave the frame within the cage so she can not come back to lay more eggs.
- The day before you graft, work the finishing colony again (meaning, rotate young larvae above the queen excluder). This will ensure that the youngest larvae and therefore lots of nurse bees are above the excluder by the time you put the cells in the next day.
- Place a frame with queen cups into the third box so the bees can clean and polish the cups before you graft larvae into them.
- It is highly recommended that you do a "practice graft" before you want to perform the "real" graft. This practice graft will ensure that you have all the equipment ready, that bees cannot escape from the swarm box, and that the finishing colony is sufficiently primed and ready to rear your queens. In many cases, the queen cells from the first practice graft are not as well fed as those in subsequent grafts.

THE "SWARM BOX"

On the day you want to graft, prepare a "swarm box" as follows. The swarm box is used as the starter colony for the grafted queen cells. It is necessary for the newly grafted larvae to be fed large quantities of royal jelly as soon as possible after grafting to obtain the highest quality queens. The swarm box is queenless and broodless and is provided with plenty of nectar, pollen and nurse bees. The glands of nurse bees are developed and ready to produce royal jelly. When packed in the swarm box with only the larvae that are grafted they will provide them plenty of royal jelly and warmth for the critical first 24 hours.

Preparing the Swarm Box (1-2 hours before grafting)

- First, place some wet sponges in the bottom of the swarm box to provide water for the bees and increase humidity. New sponges should be rinsed thoroughly before use. Then place 2-3 frames of fresh nectar (make sure the cells are open; don't use sealed honey) and lots of stored pollen in the swarm box. Shake about 4 pounds of **young** bees in the swarm box and quickly close the lid. You will need to shake from 8-10 frames of bees off unsealed brood frames to ensure you have adequate numbers of young bees in the swarm box. Take precautions not to shake the queen into the swarm box (e.g., cage the queen temporarily).
- If you have sufficient colonies and plan to rear several batches of queens, it is helpful to set up a colony exactly like the finishing colony. This colony will be used to shake bees into your swarm boxes (see instructions for setting up a finishing colony, page 51). In this way, it is very easy to find frames containing young bees because they are above the excluder feeding the larvae. Also, you do not run the risk of shaking the queen into the swarm box if you shake only from frames above the excluder.
- It is possible to shake the swarm box from the colony you plan to use as the finishing colony if the colony is very populous and healthy. Use of this technique is debatable among queen producers, however if you have a limited number of colonies, you may not have the luxury of choosing.

- Place the swarm box with nectar, pollen and young bees in a cool dark place (60-70ºF.) for at least an hour before adding the grafted cells. Make sure it is sealed tight so no bees escape. During this time the bees will perceive they are queenless and broodless.

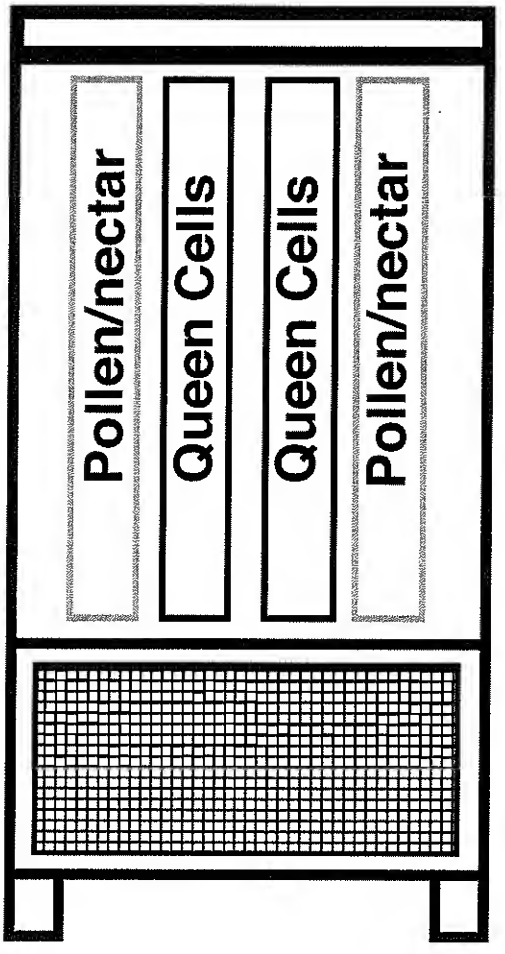


FIGURE 22.
Proper Placement of frames into swarm box to start cells.

GRAFTING

After shaking the swarm box and just before you graft, remove the frame from the breeder colony from which you will graft. This frame should now contain very young (12-24 hour old) larvae that have just hatched from eggs and are floating in large quantities of royal jelly. Wrap the frame in a damp towel (or keep it warm and humid somehow) and bring it into the room where you will perform the graft.

Grafting Room

- Grafting can be done anywhere: in the front seat of your pick-up, in the middle of the bee yard, or in a warm, humid room with adequate lighting. Obviously, an ideal place is NOT in a pick-up or in the bee yard. The ideal place to graft is in a special grafting room, close to the breeder and finishing colonies.

- The temperature in the room should be at least 75^0F, and the relative humidity should be above 50% to prevent drying of the larvae. The room can be humidified by boiling water in a pan, or by sprinkling water on the floor before grafting.

- Make sure you have a clean table and a chair that allows you to reach the table without unnecessary bending or stretching. You will need to incline the grafting frame approximately 30^o from horizontal by resting the frame on some kind of support (wood blocks, or a custom built frame rest which you can design for your grafting comfort).

- Proper lighting is critical. A bright fluorescent lamp is best because it does not project heat. It should be placed so the light shines directly into the bottoms of the cells containing the larvae to be grafted. If you have problems finding or situating adequate lighting, it is recommended you invest in a head-lamp (flashlight that sits on your forehead supported by a head band). These can be purchased at camping stores. There are excellent head-lamps that allow you to focus the beam that work very well for grafting, however they are a bit expensive ($30-40).

How to Graft

- Make sure you are comfortable, relaxed, unhurried, and have a grafting tool that you like.
- Lower the grafting tool into a cell containing a 12-24 hour old larva that is floating in a large amount of royal jelly. At this age, the larva is not much bigger than the egg but it is slightly curved. If the larva is noticeably bigger than an egg, it is too old to be grafted.
- Gently scoop the larva out of the cell by lowering the tool beside the wall of the cell and slipping it sideways under the larva and royal jelly. It is desirable to lift out some royal jelly with the larva, but this is not always possible with all grafting tools. Try not to gouge the edges or the bottom of the cell. However, it is better to gouge the cell than the larva.
- Be very careful to lift the larva out of the cell in exactly the same position you found it at the bottom of the cell. It is better to try grafting a different larva if you think you have damaged or upset the larva. It is best to insert the tool from the outside of the curve of the larva.
- Gently place the larva directly in the center of the queen cup. Getting the larva off the grafting tool (particularly the hook kind) requires practice and patience. It helps to roll the tool slightly so the larva slides off. Again, make sure to place the larva in the cell in exactly the same position you found it in the frame. Do not turn it upside down. Do not allow it to uncoil. Do not place the larva on the edges of the cup.
- As you graft, hold onto wooden cell bars at the location of the queen cup into which you are going to graft. This practice will help you keep your place so you don't have to search in each cell to figure out if you just grafted a larva into it or not.

- Many people prefer to "prime" the queen cups with royal jelly (collected from other queen cells) before grafting by placing a small drop of jelly in the bottom of the queen cups. The advantage of priming the cells is that the larva is transferred onto a bed of royal jelly and so is kept moist and is never without food. The disadvantage is that sometimes novice queen producers drown the larva in the royal jelly. Also, the royal jelly used for priming that is collected from older queen cells may of slightly different composition than the jelly fed to very young larvae. With practice, you will be able to graft larvae quickly enough to prevent the larvae from drying out without priming. **Priming with royal jelly does not improve the quality of the queens and is unnecessary.**

- When you have completed grafting into all the cells on one cell bar, check each cell to ensure all the larvae are of the same size and are placed in the center of the cell. **Regraft any cells that are not uniform in size.** Simply scoop the larva out and graft another one in its place. This step is critical. It will help ensure that the queens emerge at approximately the same time so that one doesn't emerge early and kill the rest.

- Cover the cell bar with a warm, moist towel and continue grafting into the next series of queen cells.

- When you are done grafting, insert the cell bars containing the grafted larvae into the frame adapted for holding the bars, without jarring the cells. Two to three cell bars can fit in a frame. From 60 to 100 cells can be grafted and placed in a swarm box at a time.

Placing the Grafted Cells in the Swarm Box

- Place a moist, warm towel around the grafted larvae on the cell bars to prevent them from drying out. Take the swarm box and queen cells outside. Do not open the swarm box until you are ready to insert the cell bars.
- Sharply rap the swarm box on the ground to knock the bees to the bottom of the box, open the cover, and quickly but carefully place the cell bar frames between the nectar/pollen frames as shown in the diagram below. Some bees will fly out. That's OK, you don't want those bees anyway. If they fly, they are probably older and aren't the right age to feed your queen larvae. The majority of young bees should remain in the box. It is usually not necessary to use smoke during this procedure.
- Place a pollen patty over the center of the frames. Then quickly close the cover of the swarm box. Tape it (with duct tape) if you think bees might escape, and replace it in a cool dark place for 24 hours.
- A properly prepared swarm box will be able to start six cell bars (two frames containing three bars each), or a total of 60-100 queen cells. When you open the swarm box after 24 hours, over 90% of the queen cells should be accepted. That is, the wax cells should have been enlarged evenly and the larvae should be doubled in size and very well fed. If your acceptance rate is below 75% it means you need more practice grafting and/or the swarm box did not contain enough young bees. Try again.

Placing the Queen Cells in the Finishing Colony

- After the queen cells have been in the swarm box for 24-36 hours they are ready to be transferred to the finishing colony. One finishing colony can tend 1-3 bars of new cells, or 15-48 cells depending on the strength of the colony. Once the cells are sealed, the finishing colony can tend 15-48 more new cells, plus the older cells that are sealed.
- Bring the swarm box to the apiary without jarring it unnecessarily. Open the finishing colony down to the third box. Separate the middle frames and place a cell bar frame between frames containing eggs, young larvae, and pollen as shown in figures 20 & 21 on pages 52 & 53. Place a pollen supplement patty over the queen cells before closing the colony.
- Return the bees and nectar/pollen frames from the swarm box to the colony from which they came.
- If many queens are to be reared, queen cells may be introduced into the finishing colony or colonies using a careful rotation system. Three or four days after a graft is given to the finishing colony, the sealed or nearly sealed cells are moved over a frame near older larvae, and the newly started cells from the swarm box are put in their place. This process continues, the oldest cells being pushed away from the center as new cells are added to the finisher. Each time a new graft is placed in the colony, young larvae should be rotated above the excluder.
- Be sure to note the day the cells are to be removed from the finishing colony. Do not allow the queens to emerge in the finishing colony.

Removing Queen Cells from Finishing Colony

- Ten to eleven (10-11) days after the larvae were grafted (or 9 days after placing them in the finishing colony), remove the queen cells from finishing colony. If 12-24 hour old larvae were grafted, the queens should be 14 days old when they are removed. Remember, during development, the egg hatches on day 3, you grafted on day 4, the larva is sealed in a cell on day 8-9, the pupa emerges as an adult on day 15-16. Therefore, your queens are due to emerge during the next two days. Again remember, if the queen cells are left to emerge within the finishing colony, the first queen out will kill all the other queens in their cells.
- Remove the cells by gently pulling out the frame containing the cells. Brush the bees off the queen cells VERY GENTLY using a soft bee brush.
- **It is very important at this stage to keep the queen cells in a vertical position. Do not tip the cells more than 10-20^0 Do not jar the cells. Do not damage them with the bee brush.**
- Take the queen cells into your grafting room and "candle" them to cull out those that may be small, or below standard. By holding the cell up to a light, the outline of the developing queen can be seen through the cell. Any that are small or appear abnormal should be discarded. The size of the cell is not always a good indication of the quality of the queen. A good, large queen can be in a small cell and a small queen can be in a large cell.
- Queen cells that have been cared for properly will be uniform in shape. Uneven or misshapen cells are indications that the swarm box and/or finishing colonies are not functioning properly and the resulting queens will not be satisfactory.
- The best queen cells should either be placed in an incubator or introduced into a mating nuc or colony that is queenless and ready to accept a queen cell.

ALTERNATIVES TO GRAFTING

For many people, grafting larvae is a difficult and frustrating experience. Either they can not see the larva well enough to pick it up, or they are unable to transfer the larvae without damaging them. There are several alternative systems which bypass the grafting step.

One system involves purchasing a queen rearing kit. The breeder queen is placed in a special cell comb box fixed within a standard frame and she is allowed to lay eggs within the box. Some of the cells in which the queen lays eggs are fitted with removable plugs. Four days after the queen is confined in the box, the plugs (bases of the cells), which contain 12-24 hour old larvae, are removed and attached to a cell bar. They are then treated as grafted queen cells, and can be placed in a swarm box to be fed royal jelly.

Advantages of using a kit are: 1) There is no manipulation of the larvae with a grafting tool, therefore there is a decreased chance of damaging the larvae; and 2) There is a reduced requirement for accuracy of eye and steadiness of hand on the part of the beekeeper.

Disadvantages of using a kit are: 1) The kit is relatively expensive; 2) There are a number of steps that must be taken to prepare the equipment for use, and there are many little parts which may be difficult to deal with; and 3) It may be difficult to get the breeder queen to lay eggs in the plastic cells of the cell comb box. This can be remedied by painting the plastic cells with a thin coat of melted beeswax.

We do not endorse any particular kit that is available. Information on kits we are aware of can be received from the sources listed below. Before purchasing the unit it is advisable to request a copy of the instructions for the device and possibly a sample so you may determine its acceptability.

Jenter Queen System:
Brushy Mountain Bee Farm, 1-800-BEESWAX

Nicot Queen Breeding Device
Orr Apiaries, (613) 397-3280
Mann Lake, 1-800-233-6663

MATING YARDS

It is important to carry the queen cells to the mating yard in some sort of protective holder. Care must be taken to not chill or overheat the cells. The cells must be kept in a vertical position, and must not be jarred. A small cooler fitted with a hot-water bottle and a Styrofoam or foam-rubber block with holes to hold the queen cells may be used for transport. There are also commercially available plastic queen cell holders.

Requeening Existing Colonies

- Remove the queen from the colony which is going to be requeened. One to three days later, introduce a queen cell that is due to emerge in 1-2 days in the center of the brood nest. Gently press the cell into the comb near some emerging brood. The cell should be in a vertical position, and care must be taken not to damage the cell with the adjacent frames. The queen should emerge, mate, and be laying eggs within two weeks. When the queen has produced several frames of brood, mark her (see instructions for Marking Queens, below).

Introducing Queen Cells into Divides

- A divide is made 1-3 days prior to introducing the queen cell. Follow the same procedure for requeening existing colonies. Queen cells are more readily accepted into divides because they have fewer bees and consist of mostly young bees.

Mating Nuclei

- There are many types of mating nuclei, ranging from deep hive bodies divided into compartments, to narrow nuc boxes which hold 3-5 deep frames, to "mini" or "baby" nuclei. Plans for making mating nucs are given on pages 40 to 48.

- Whichever type of mating nuc is used, it should contain at least one comb of sealed brood with the adhering bees, one comb of honey, and one empty comb. Additional young bees will need to be shaken into the nucs. Mini-nucs will need to be fed sugar-syrup.
- Close the entrance of the mini-nucs for 24 hours after they are stocked to allow the small colony time to become organized before introducing queen cells.
- A new queen cell is gently pressed into the comb containing sealed brood. The cell should be in a vertical position, and care must be taken not to damage the cell with the adjacent frames. Some bee suppliers manufacture "cell protectors" into which the queen cells can be placed to prevent damaging them.
- Remember, the queen will emerge 1 or 2 days after the cell is introduced, and will mate 5-7 days later. Three to four days after mating the queen will begin laying eggs. Therefore, she should begin laying eggs about 8-11 days after the cell is introduced. Refer to the calendar or wheel of important events.
- Remove the queen after she has laid eggs in at least one frame. It is wise to wait 5-7 days after the queen begins laying eggs before removing her so her brood pattern can be inspected. The laying queen can then be sold, or used to requeen an existing colony.
- Further restocking of the mating nuclei will probably not be necessary following the removal of the first laying queen, since there will be brood present in various stages of development. However, continued feeding of sugar-syrup will be necessary.
- If the new queen did not emerge, did not mate, or was not accepted in the mating nuc, inspect the frames for natural queen cells or a virgin queen, and supply brood, bees, and/or feed as necessary to restock the nuc before introducing another queen cell.
- For an excellent account on "Mating the Queen" refer to Chapter 4 in *Contemporary Queen Rearing*, by H. Laidlaw.

MARKING QUEENS

- It is a very wise idea to mark all production queens and it is **essential** to mark all breeder queens. When queens are marked, they are easier to spot within the colony. If a different color is used each year to mark queens, it is also possible to know how old the queen is at a glance by the color of her mark. Finally, it is critical to know if the queen you are evaluating for breeder stock is still in the colony when you are ready to rear queens from her. The only way to ensure that the queen has not been superseded is to mark her.
- Use Testors enamel paint to mark queens. It will last a long time, dries quickly, and comes in many colors. Some bee suppliers also sell paints which come with a handy applicator.
- To mark a queen, gently pick her up by her wings or thorax being careful not to crush her. Place a small dab of paint on her thorax using a trimmed paintbrush, a small blunt stick, or the applicator that comes in commercially available paint. Be very careful not to paint the queen's eyes.
- Make sure the paint has dried before returning the queen to the colony. Carefully replace the queen on a brood frame.
- A good way to practice marking queens is to practice on young nurse bees that you pluck off a comb containing eggs and larvae. Picking up queens off a comb is much easier than picking up workers, plus queens rarely sting. If you perfect marking workers without getting stung or damaging them, you will certainly be able to successfully mark queens.
- Industry Standard colors are listed on the chart below. The number indicates the last digit of the year the queen was mated. i.e. 1993 = 3.

0 or 5	Blue
1 or 6	White
2 or 7	Yellow
3 or 8	Red
4 or 9	Green

RECORD KEEPING

Record keeping is absolutely essential and is the key to successful queen rearing and selection. Records must be kept of all potential breeder colonies, the breeder colonies in use, the drone mother colonies, and grafting procedures. Inbreeding can be avoided by keeping precise records of which breeder queens and drone mother colonies were used each year. Pedigrees should be maintained of the queen and drone lines to avoid using the same breeder and drone mother colonies year after year.

Breeder Colonies

- An example of a record sheet for evaluating potential breeder colonies is shown on the next page. This is just a sample and should be adjusted to suit your own needs.

Grafting Notes

- Queen rearing demands that the beekeeper maintain a very strict schedule and accurate records. You will need a system to record when larvae were grafted, from what queen line, in which finishing colony they were placed, and when they are due to emerge. A notebook should be kept in the grafting room. A sample graft record table can be found in H. Laidlaw, *Contemporary Queen Rearing*.
- It is a good idea to record the queen line and date the cells were grafted on the cell bars. This helps avoid confusion when placing and removing the queen cells in the swarm box and finishing colony. See section on "cell bars and frames" on page 27.

NOTES

FIGURE 23a.
Sample record sheet to record data on individual queens.

QUEEN RECORD

Page ____

Queen # _____ Marked _____ Clipped _____

Emerged _____ From Nuc _____ To _____

Mother _____ Mating (type/yard) _____

Observation or manipulation	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
# Brood Boxes										
# Honey Supers										
Colony Manipulation										
Temper										
Brood: Amount										
Appearance										
Disease: AFB										
:EFB										
Chalkbrood										
Mites :Tracheal										
Varroa										
Propolis										
Swarming										
Supercedure										
Honey Removed										
Combs + or -										
Foundation + or -										
Honey Stores										
Pollen Stores										
Wintering										

FIGURE 23b.
Record sheet to record data on individual queens.

QUEEN RECORD

Page ____

Queen # ____________ Marked ____________ ____________

____________ ____________ ____________

____________ ____________ ____________

Observation or manipulation	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date

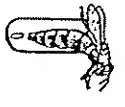
-16 Begin Stimulating feeding of drone, breeder and finishing colonies	-15  Queen lays drone eggs (unfertilized)	-14	-13	-12	-11	-10
-9	-8	-7	-6	-5	-4	-3
-2	-1 Put empty frame in breeder colony	0  Confine queen on frame (PM). Queen lays fertilized eggs.	1 Remove queen from frame	2	3 Eggs Hatch Work finishing colony and put cells in for cleaning	4 Shake swarm box GRAFT
5 Transfer cells to finishing colony	6	7	8  Queen Cells sealed Drones emerge	9	10	11

FIGURE 24a.
Queen rearing calendar of important events, Part 1.

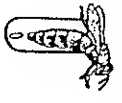
12 	13  Make up nuclei colonies or dequeen colonies for virgins	14  Remove cells from finishing colony	15  Virgins emerge	16	17	18
19	20	21 Mating Flights begin	22	23	24	25
26	27	28  Queen begin laying eggs	29	30	31	32
33	34	35	36	37	38	39

FIGURE 24b.
Queen rearing calendar of important events, Part 2.

A REVIEW OF IMPORTANT POINTS FOR REARING GOOD QUEENS

- The breeder queens should be selected carefully using strict criteria. Accurate records should be maintained of the performance of all potential breeder colonies for a year.

  Basic criteria:

  a. **Good honey production**

  b. **Wintering capability**

  c. **Gentle temper and ease of management**

- It is extremely critical that precise records be maintained on the breeder colonies. Make sure your breeder queens are marked.

- Breeder colonies should pass the selection criteria test over a year's time. Rapid selection based on one or two inspections in the spring or fall may be very misleading and lead to the propagation of undesirable characteristics.

- The larvae to be grafted should be well fed from the time they hatch.

  — The breeder colony must have plenty of young nurse bees.

  — If plenty of natural nectar and pollen is not available to the breeder colony it must be supplied to them.

- While grafting, the larvae must be kept in a warm and humid environment. The larvae should not be allowed to dry out.

  — The grafting room must be warm and humid (80° F. >50% RH).

  — The larvae in the frames and/or queen cups should be wrapped in a warm damp towel or over a pan of warm water.

  — The grafted larvae should be placed in the swarm box as soon as possible after grafting.

- While in the swarm box, the bees must continue to care for and feed the larvae.
  - — Be sure the swarm box contains plenty of young nurse bees and at least two frames of nectar and pollen.
  - — Place wet sponges in the bottom of the swarm box to supply water and humidity to the bees.
  - — Keep the swarm box in a cool, dark place for 24 hours.
- The cells must be handled gently and kept in their natural position to prevent damage to the developing queens.
  - — When moving cells avoid jarring them or moving the frame with jerking motions.
  - — When moving cells always keep them in the vertical position. Tipping can dislodge the developing queen or damage her wings.
  - — If you need to remove bees brush them off gently. Do not remove bees by shaking the cells.
- After the cells are sealed they must be kept at the proper temperature and humidity in the finishing colony or incubator until ready for use. (93-94^{0}F., 70-80% RH)
  - — Be sure the finishing colony contains enough bees to keep the cells at the proper temperature and humidity.
  - — Be sure the incubator is pre-heated so the temperature and humidity will be constant and proper.
- Cells should be "candled" to cull out those queens that are small, or below standard.
  - — The size of the cell is not always a good indication of the quality of the queen. A good large queen can be in a small cell and a small queen can be in a large cell.
  - — By holding the cell up to a light, the outline of the developing queen can be seen through the cell. Any that are small or appear abnormal should be discarded.

- There must be sufficient drones of proper age in selected drone mother colonies for mating.
  - — The same criteria should be used to choose the drone mother colonies as was used to choose the breeder queens.
  - — Encourage drone rearing by supplying drone comb, pollen, and honey (or sugar syrup).
  - — Carefully time when queens will mate to coincide with when the drones are sexual mature.
  - — Place as many drone mother colonies as possible within 1/4 mile of the apiary from which the queens are flying.
- Rear queens when the weather will permit good mating.
  - — The best time to rear queens is when the bees have the impulse to swarm. This will ensure that resource and weather conditions are favorable.
- Mark your queens.
  - — After the queen has emerged, she should be marked with a colored dot (Testors enamel paint) on the thorax. This is the only way you will know you are following your breeder line and not a supercedure queen.

FINAL WORDS

As with everything in beekeeping, there are MANY ways to rear queens. The techniques described in this manual include only some of the many ways to produce quality queens. For other methods, we refer you to the books referenced at the end of this manual. We encourage you to try different methods. Dr. Farrar, a wise and renown beekeeper and bee researcher stressed,

"Poorly reared queens of productive stock generally will be inferior to well-reared queens from less productive stock."

Therefore, rear high quality queens and encourage drone production so your queens will mate with high quality drones. Cull inferior queens and colonies. Reproduce superior performing colonies. Take pride in your work and your stock. Good luck!

SUGGESTED READING

Brother Adam. 1987. *Breeding the Honeybee.* Northern Bee Books, Mytholmroyd: Hebden Bridge

Doolittle, G. M. 1888. *Scientific Queen-Rearing.* American Bee Journal, Hamilton, IL

Farrar, C.L. 1968. Productive management of honey-bee colonies. *Amer. Bee J.* 108 Nos. 3-10. (Reprinted in the *Amer. Bee J.* in eight parts, 1993).

Graham, J. M. (Ed.) 1992 *The Hive and the Honey Bee.* Revised Edition. Dadant & Sons: Hamilton, IL.

Jurica, C.A. 1985. *Practical Queen Production in the North.* Apollo Books: Winona, Minn. (Available from Jurica Apiaries, 325 Wells Street, Johstown, NY, 12095)

Laidlaw, H.H. Jr. 1979. *Contemporary Queen Rearing.* Dadant & Sons: Hamilton, Ill.

Morse, Roger A., 1994, *Rearing Queen Honey Bees* Second edition. ISBN 1-878075-05-5. Wicwas Press: Cheshire, CT 06410-0817

Pellet, F.C. 1929. *Practical Queen-Rearing.* 4th Ed. Dadant & Sons, Hamilton, Ill.

Spivak, M & Reuter, GS (2006) Honey Bee Diseases and Pests. A Companion to Beekeeping in Northern Climates. University of Minnesota Extension Service. Order on-line: www.extension.umn.edu/honeybees/ or by phone 1-800-876-8636.

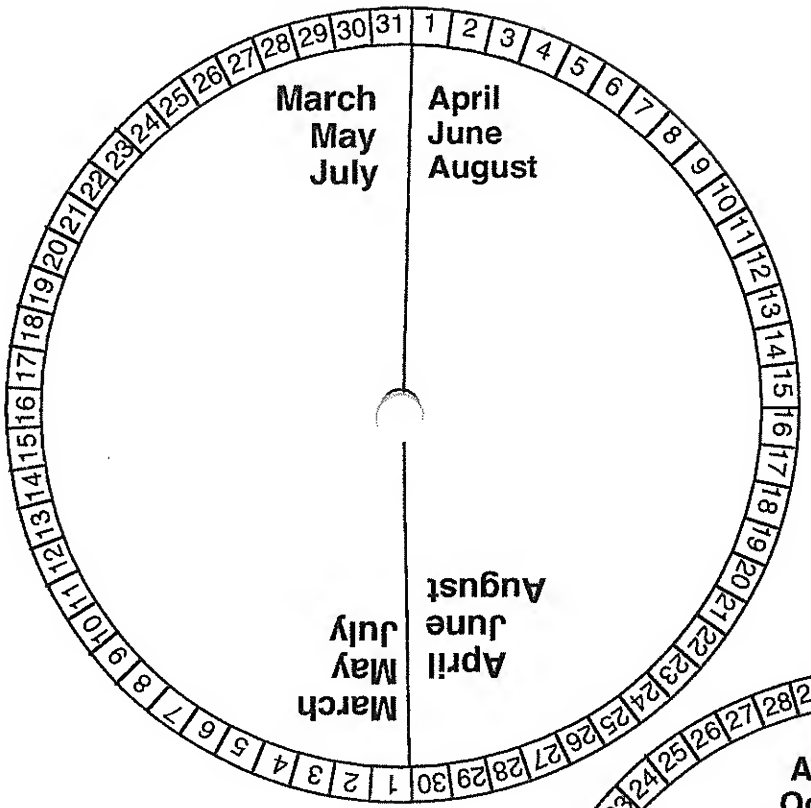
Taber, S. III. 1987. *Breeding Super Bees.* The A. I. Root Co., Medina, Ohio

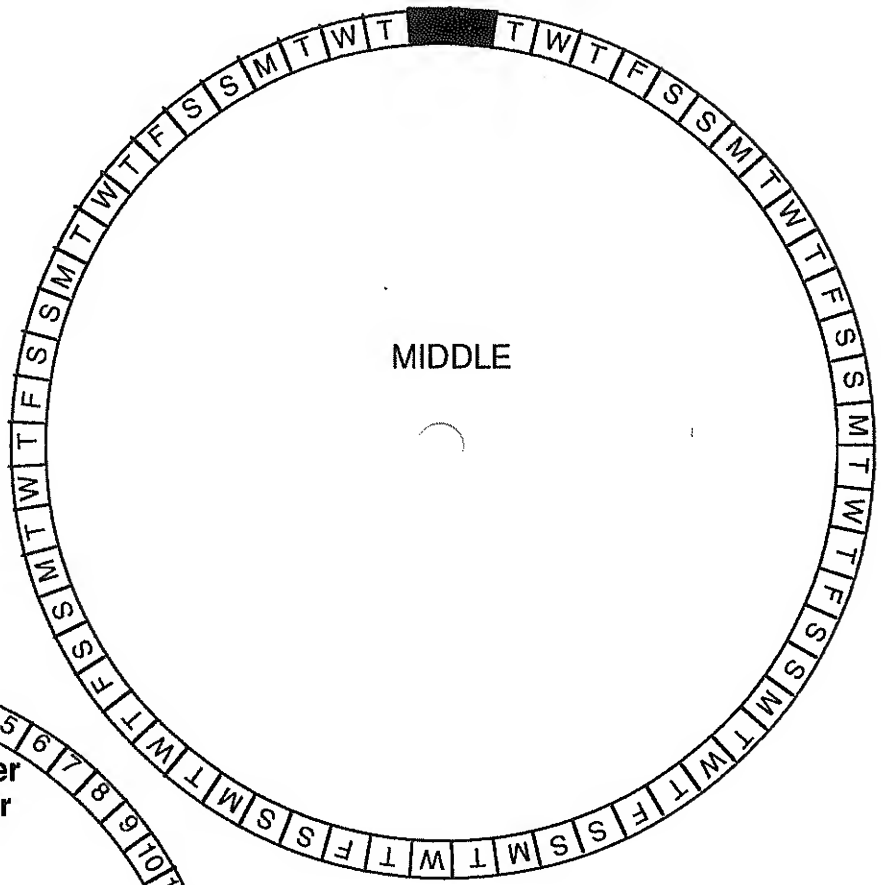
Winston, M. 1987. *The Biology of the Honey Bee.* Harvard University Press, Cambridge, MA.

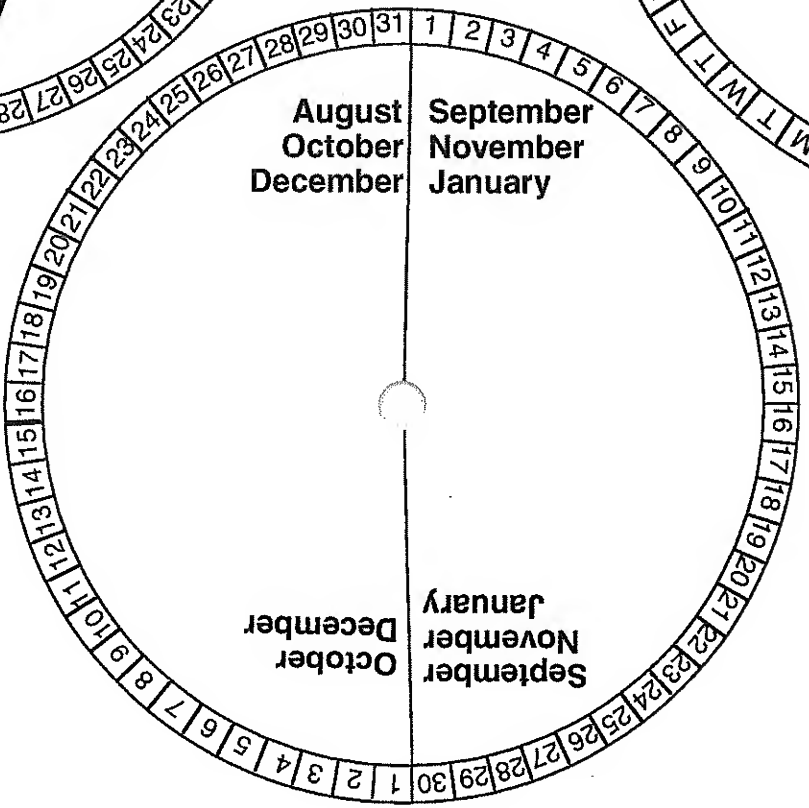
REFERENCES

University of Minnesota Apiculture Lab web site <>
www.extension.umn.edu/honeybees/

A video is available to accompany this manual titled "Successful Queen Rearing" It is available on line www.extension.umn.edu/honeybees/ or by phone 1-800-876-8636.







To make wheel cut these three wheels out. Punch holes in the center of the wheels and the wheel on page 79 of the manual. Place pin of the snap* into hole of page 79 from the back. Next place the middle wheel with the days of the week on the pin. Put the date wheels on the pin with the months you want to use on the top. Snap the other end of the snap on.

*Snaps available at most dry good stores. We used a size 4.

FIGURE 23

Queen rearing wheel of important events. To use this wheel first pick out a day you want to graft or the day you want the queens to emerge. Now set the date you have picked with the corresponding event. Line up the day of the week with the correct date and the wheel will tell you the day and date for each event in that queen rearing cycle.